INTERSTATE 405 Corridor Program
Congestion Relief & Bus Rapid Transit Projects

APPENDIX T9

WSDOT Illumination Design For Transportation Applications

I-405, SR520 to SR522 Stage 1 (Kirkland Stage 1)

Request For Proposal
July 15, 2005

Washington State Department of Transportation

Illumination Design for Transportation Applications

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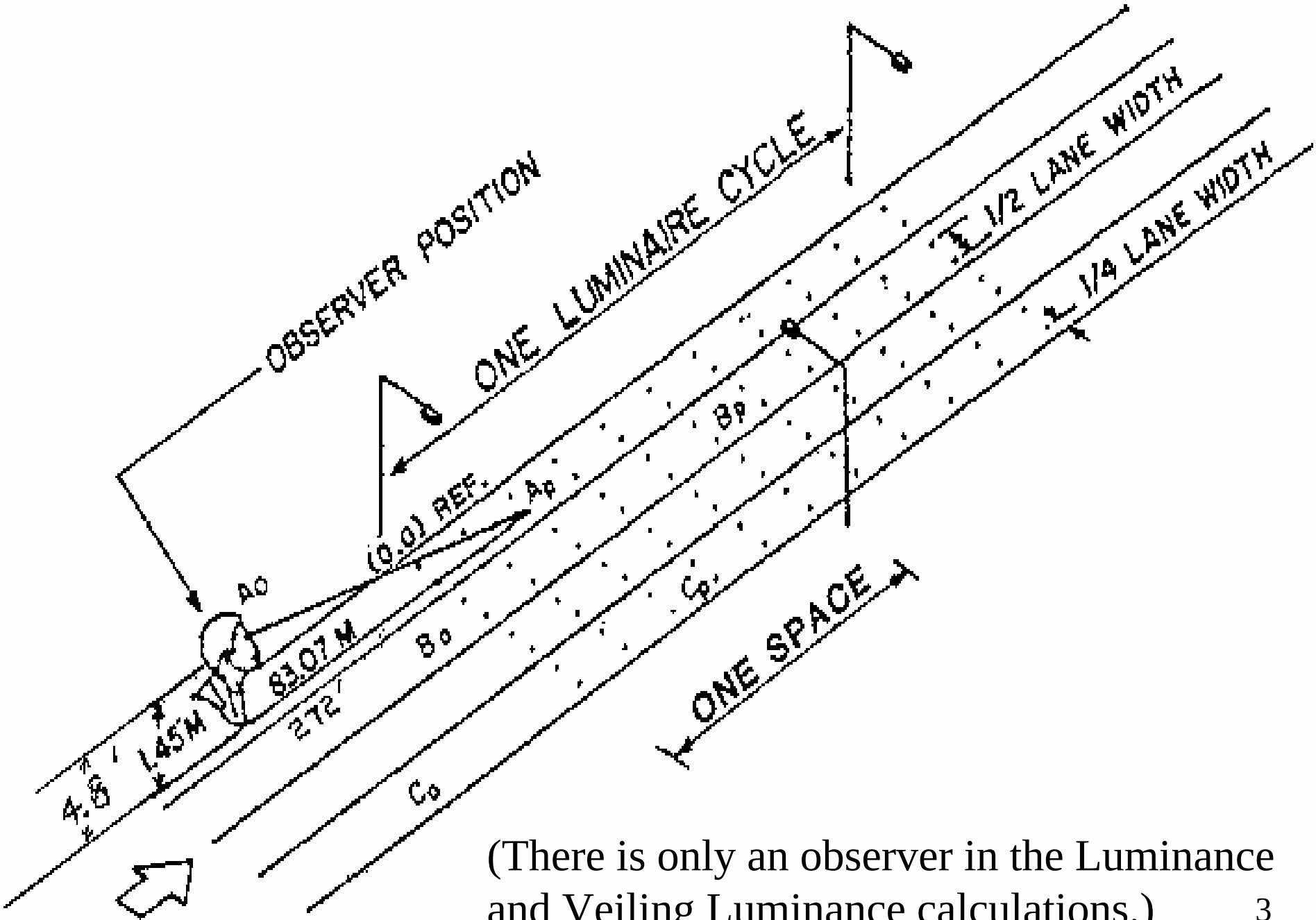
Definitions

- Illumination - the intensity of light per unit of area.
- Luminance - luminous intensity, expressed in candles per unit projected area for the luminous surface.
- Veiling Luminance - The stray light produced within the eye by the light source that alters the apparent brightness of an object within the visual field and the background against which it is viewed.

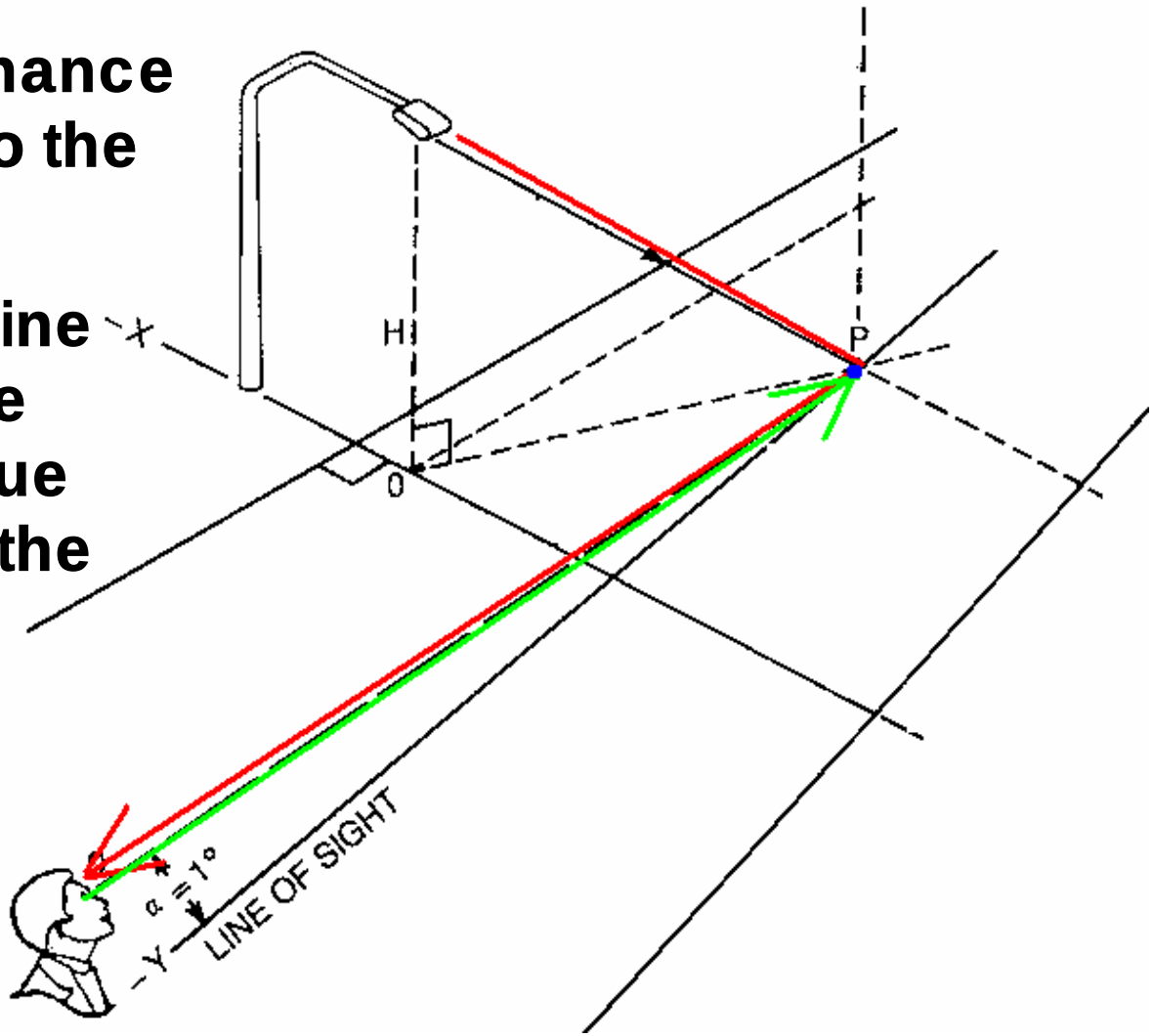


(There is only an observer in the Luminance and Veiling Luminance calculations.)

Luminance

Red → **Path of Luminance from the luminaire to the observers eye.**

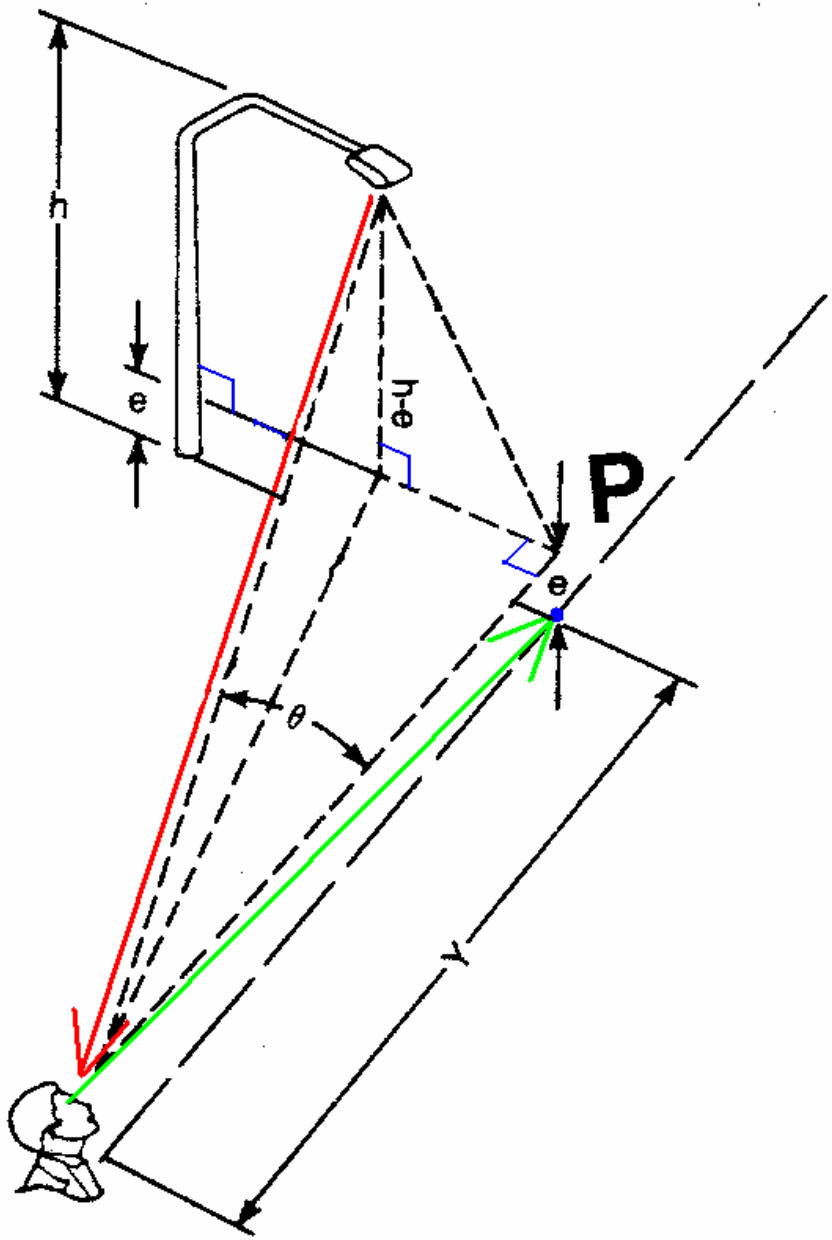
Green → **Observers line of sight looking at the Luminance point value to be calculated on the pavement surface.**



Veiling Luminance

Red → Path of Veiling Luminance(Disability Glare) from the luminaire to the observers eye.

Green → Observers line of sight looking at the Veiling Luminance point value(Lv) to be calculated on the pavement surface.



Definitions - continued

- Lamp lumens - The total output from a lamp in lumens. (A lumen being a unit of luminous flux.)
- Luminous Flux - the rate of flow of light radiation.
- Foot-candle - The illumination of a surface one square foot in area on which is uniformly distributed a flux of one lumen. A foot-candle equals one lumen per square foot.

Definitions - continued

- Minimum light level - The minimum light intensity of illumination at any point within the design area measured just prior to relamping the system.
- Minimum average light level - The average of all light intensities within the design area measured just prior to relamping the system.
- Uniformity Ratio - The ratio of the minimum average light level on the design area to the minimum light level of the same area.

Definitions - continued

- Dirt Factor - the amount of environmental contamination deposited on the reflector, refractor or luminaire bulb. Expressed as percentage of light transmission loss at end of life / relamping time compared to new installation. (DF) = 0.85 (RP-8-00 page 27)
- Lamp Lumen Depreciation Factor - the factor used in illumination calculations to relate initial rated output to the anticipated output at replacement time. (LLDF) = 0.73 (GE Catalog Dec. 1995 - section 9050 page 2)
- Light Loss Factor (Maintenance factor) Percentage of light degeneration through the life of the lamp. (DF) 0.85 x (LLDF) 0.73 = 0.62LLF

Dirt Factor

ANSI / IESNA RP-8-00

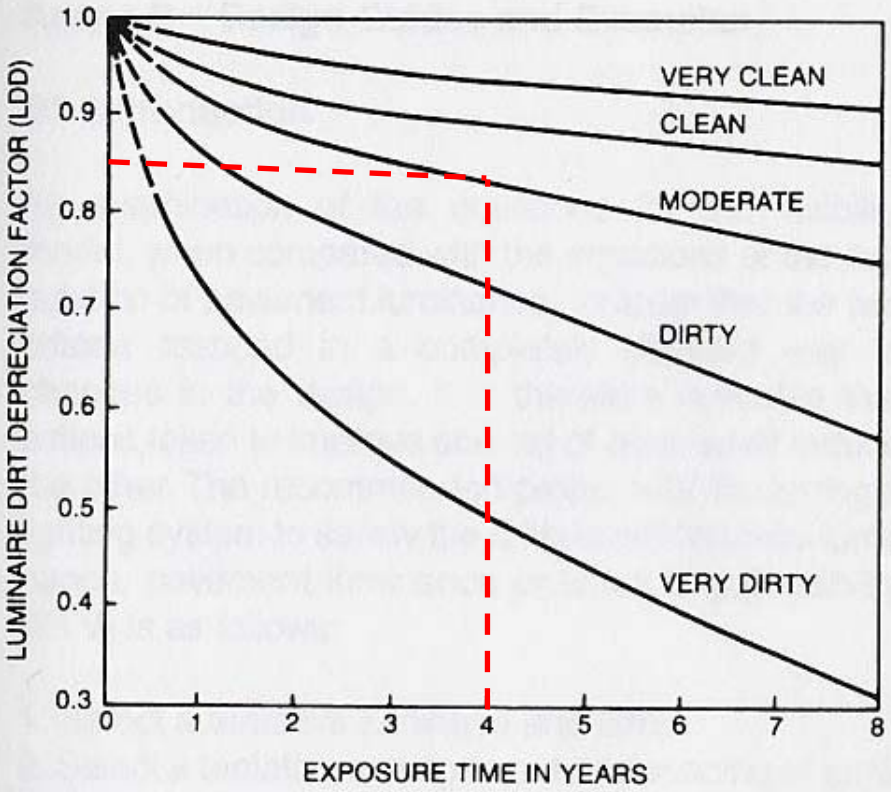


Figure A5. Luminaire Dirt Depreciation (LDD) factors.

SELECT THE APPROPRIATE CURVE IN ACCORDANCE WITH THE TYPE OF AMBIENT AS DESCRIBED BY THE FOLLOWING EXAMPLES:

VERY CLEAN—No nearby smoke or dust generating activities and a low ambient contaminant level. Light traffic. Generally limited to residential or rural areas. The ambient particulate level is no more than 150 micrograms per cubic meter.

CLEAN—No nearby smoke or dust generating activities. Moderate to heavy traffic. The ambient particulate level is no more than 300 micrograms per cubic meter.

MODERATE—Moderate smoke or dust generating activities nearby. The ambient particulate level is no more than 600 micrograms per cubic meter.

DIRTY—Smoke or dust plumes generated by nearby activities may occasionally envelope the luminaires.

VERY DIRTY—As above but the luminaires are commonly enveloped by smoke or dust plumes.

Lamp Lumen Depreciation Factor

HIGH PRESSURE SODIUM LAMP DATA

ORDERING ABBREVIATION	ANSI CODE	FINISH	LIGHT CENTER LENGTH INCHES	INITIAL LUMENS	LAMP LUMEN DEPRECIATION	
					MEAN	END OF LIFE
35-WATT–LIFE AT 10 HOURS/START = 16,000 HOURS						
LU35/Med	S76-HA-35	Clear	3-13/32	2,250	0.90	0.73
LU35/D/Med	S76-HB-35	Diffuse	3-13/32	2,150	0.90	0.73
50-WATT–LIFE AT 10 HOURS/START = 24,000 + HOURS						
LU50/Med	S68-XX-50	Clear	3-13/32	4,000	0.90	0.73
LU50/D/Med	S68-YY-50	Diffuse	3-13/32	3,800	0.90	0.73
LU50	S68-MS-50	Clear	5	4,000	0.90	0.73
LU50/D	S68-MT-50	Diffuse	5	3,800	0.90	0.73
70-WATT–LIFE AT 10 HOURS/START = 24,000 + HOURS						
LU70/Med	S62-LG-70	Clear	3-13/32	6,400	0.85	0.77
LU70/D/Med	S62-LH-70	Diffuse	3-13/32	5,950	0.85	0.77
70-WATT–LIFE AT 10 HOURS/START = 24,000 + HOURS						
LU70	S62-ME-70	Clear	5	6,400	0.85	0.77
LU70/D	S62-MF-70	Diffuse	5	5,950	0.85	0.77
100-WATT–LIFE AT 10 HOURS/START = 24,000 + HOURS						
LU100/Med	S54-SG-100	Clear	3-13/32	9,500	0.90	0.73
LU100/D/Med	S54-SH-100	Diffuse	3-13/32	8,800	0.90	0.73
LU100	S54-SB-100	Clear	5	9,500	0.90	0.73
LU100/D	S54-MC-100	Diffuse	5	8,800	0.90	0.73
150-WATT–LIFE AT 10 HOURS/START = 24,000 + HOURS						
LU150/Med	S55-RN-150	Clear	3-1/2	16,000	0.90	0.73
LU150/D/Med	S55-RP-150	Diffuse	3-1/2	15,000	0.90	0.73
LU150/55	S55-SC-150	Clear	5	16,000	0.90	0.73
LU150/55/D	S55-MD-150	Diffuse	5	15,000	0.90	0.73
LU150/100	S56-SD-150	Clear	5	15,000	0.90	0.73
LU150/100/D	S56-SE-150	Diffuse	5	14,000	0.90	0.73
200-WATT–LIFE AT 10 HOURS/START = 24,000 + HOURS						
LU200	S66-MN-200	Clear	5-3/4	22,000	0.90	0.73
250-WATT–LIFE AT 10 HOURS/START = 24,000 + HOURS						
LU250	S50-VA-250	Clear	5-3/4	28,000	0.90	0.73
LU250/D	S50-VC-250	Diffuse	5	26,000	0.90	0.73
LU250/S	S50-VA-250	Clear	5-3/4	30,000	0.90	0.73
310-WATT–LIFE AT 10 HOURS/START = 24,000 + HOURS						
LU310	S67-MR-310	Clear	5-3/4	37,000	0.90	0.73
350-WATT–LIFE AT 10 HOURS/START = 18,000 + HOURS						
LU350	S129-AG-350	Clear	5-3/4	50,000	0.90	0.73
400-WATT–LIFE AT 10 HOURS/START = 24,000 + HOURS						
LU400	S51-WA-400	Clear	5-3/4	50,000	0.90	0.73
LU400/D	S51-WB-400	Diffuse	7	47,500	0.90	0.73
750-WATT–LIFE AT 10 HOURS/START = 24,000 + HOURS						
LU750	S111-NH-750	Clear	6-7/8	110,000	0.90	0.73
1000-WATT–LIFE AT 10 HOURS/START = 24,000 + HOURS						
LU1000	S52-XB-1000	Clear	8-3/4	140,000	0.90	0.73

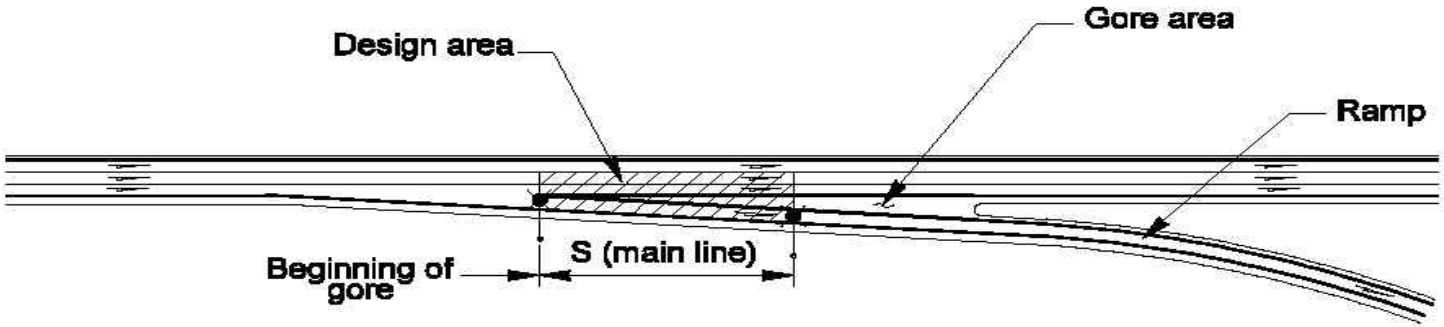
Definitions - continued

- Type III Medium Cutoff Fixture - Type I, II, III & IV are designations for asymmetrical (noncircular) distribution patterns. A “Type III” projects light further across the street (transverse) than a “Type II” and less far across the street than a “Type IV”.
- “Medium” is the distance up and down the highway (longitudinal) a luminaire directs light. This is in the range of >2.0xMH(mounting height) & < 4.0xMH (approx.).
- “Cutoff” - tells how much light a luminaire directs above 80 & 90 degrees vertical. A cutoff fixture directs almost no light (2% - 3%) above 90 degrees.

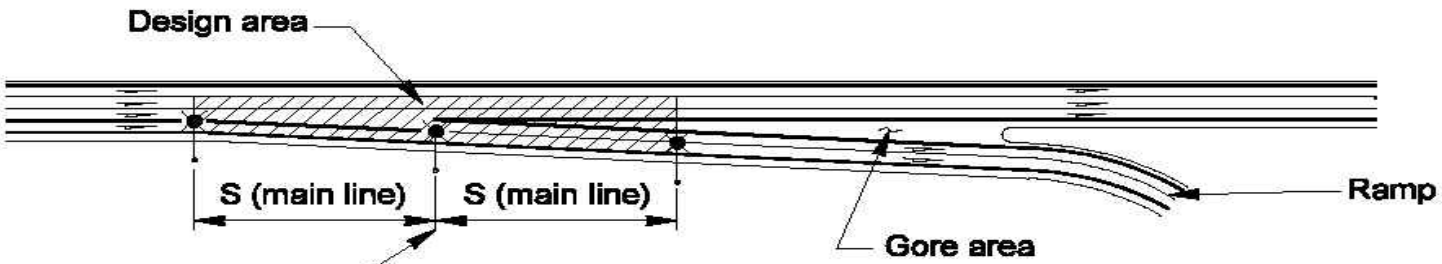
Required Illumination

- The State is responsible for illumination on state highways with partial, modified or full limited access control in any location. (DM 840-2 (1))
- Cities are responsible for illumination on state highways without WSDOT established access control located within their corporate limits. (DM 840-2(1))

Freeway Off Ramps and On Ramps (2)



Single Lane Off Connection
(Light standards can be shifted up to 100 ft from the beginning of the gore.)



Two Lane Off Connection
(Light standards can be shifted up to 100 ft from the beginning of the gore.)

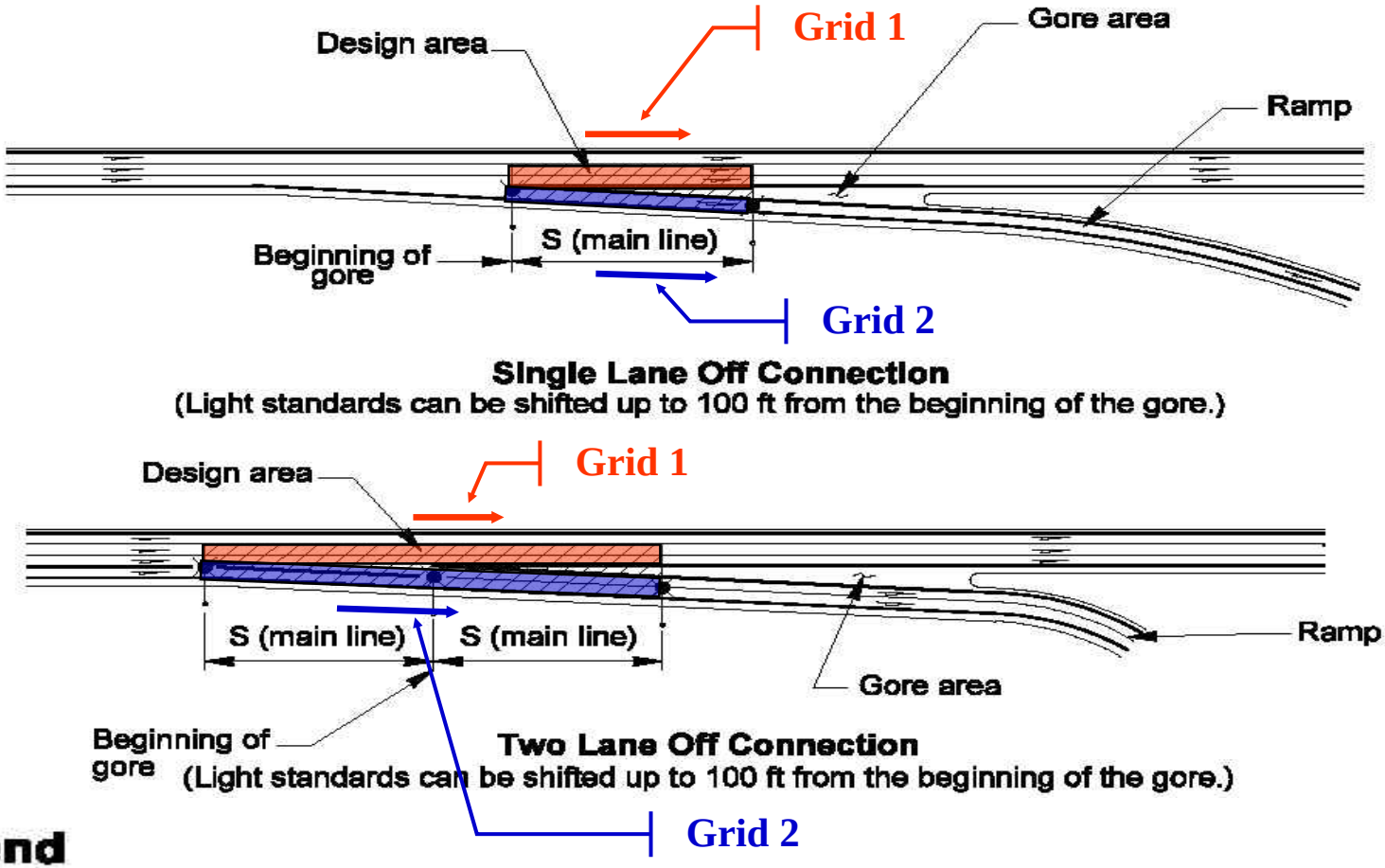
Legend

S Distance between light standards that will result in an average light level that exceeds the requirements of figure 840-6.

Light standards with mast arm mounted luminaire. (Locations are typical and not mandatory.)

RI(2) DM page 840-6 & DM figure on page 840-11

How to place Luminance & Veiling Luminance Grids

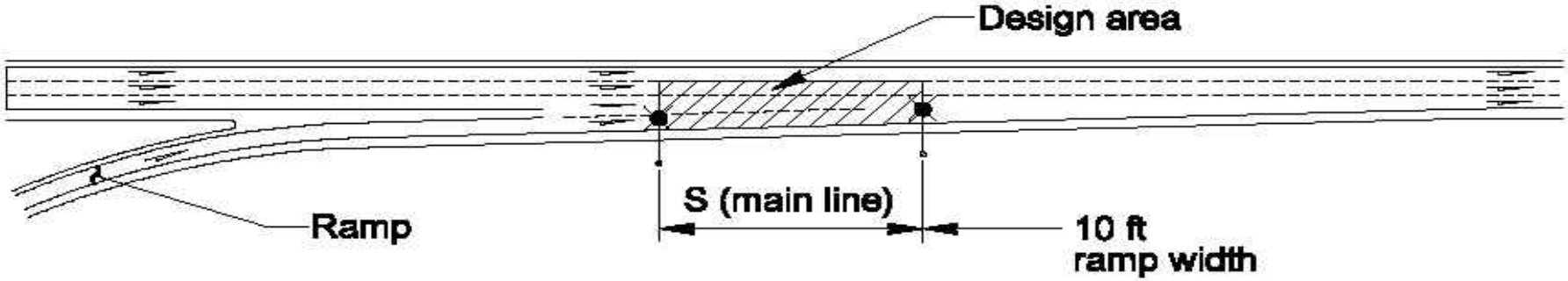


Legend

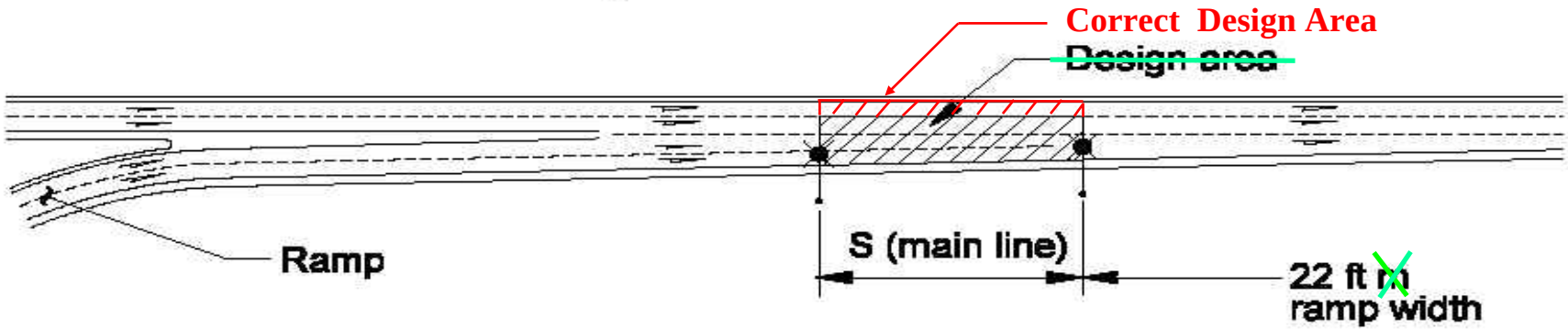
S Distance between light standards that will result in an average light level that exceeds the requirements of figure 840-6.

Light standards with mast arm mounted luminaire. (Locations are typical and not mandatory.)

Freeway Off Ramps and On Ramps (2)



Single Lane On Connection



Two Lane On Connection

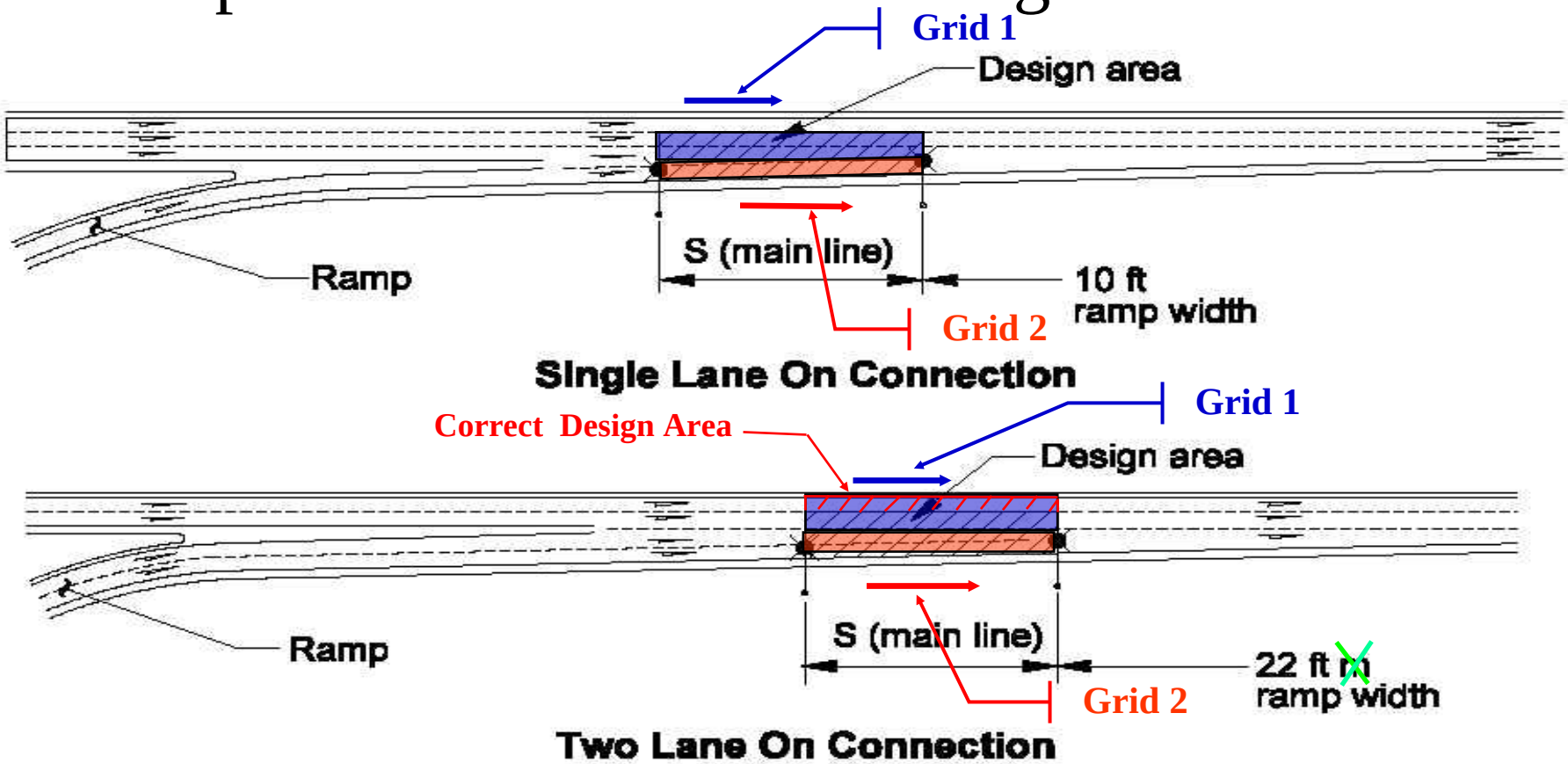
Legend

S Distance between light standards that will result in an average light level that exceeds the requirements of figure 840-6.

Light standards with mast arm mounted luminaire. (Locations are typical and not mandatory.)

RI(2) DM page 840-6 & DM figure on page 840-11

How to place Luminance & Veiling Luminance Grids

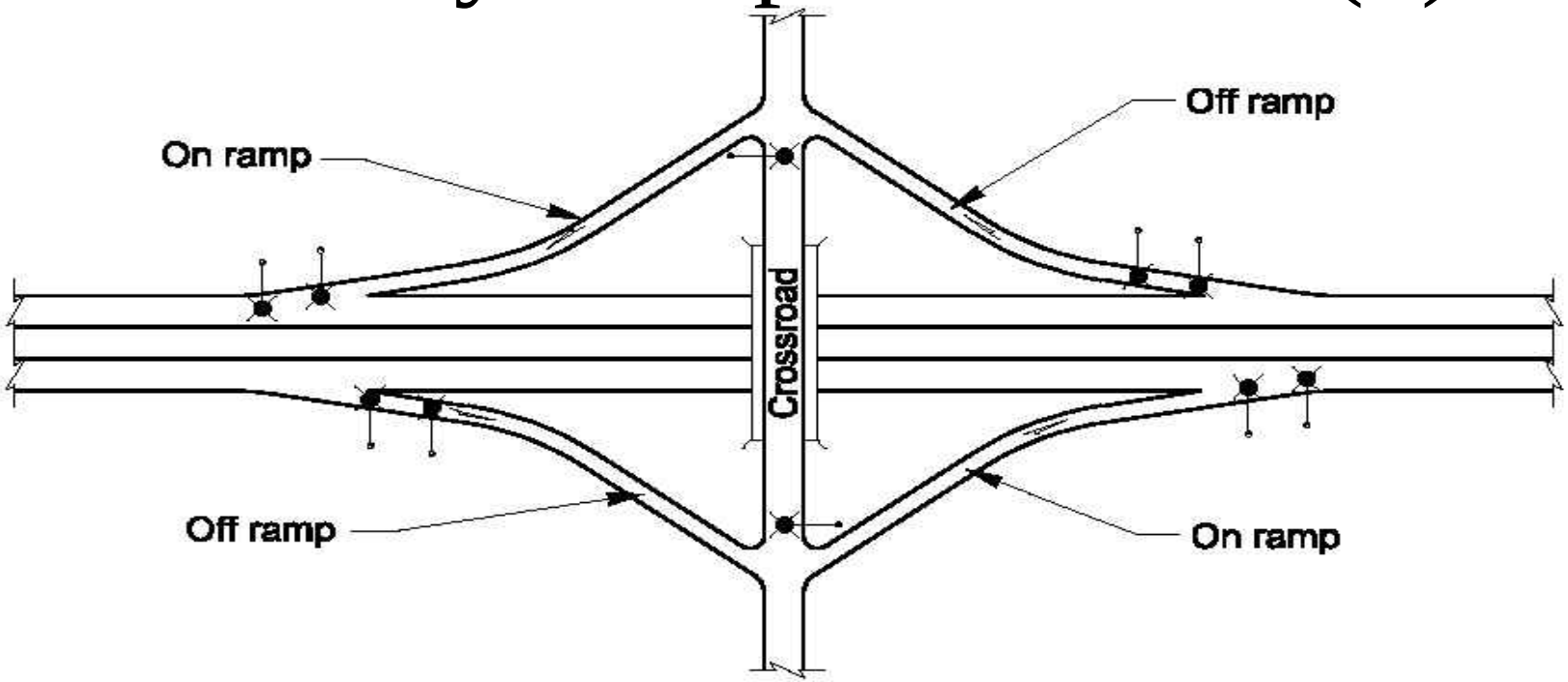


Legend

S Distance between light standards that will result in an average light level that exceeds the requirements of figure 840-6.

Light standards with mast arm mounted luminaire. (Locations are typical and not mandatory.)

Freeway Ramp Terminals (3)



Required Illumination for a Typical Diamond Interchange
(Shown for single lane ramp connection and a two lane crossroad without channelization.)

Legend

S Distance between light standards that will result in an average light level that exceeds the requirements of figure 840-6.

Light standards with mast arm mounted luminaire. (Locations are typical and not mandatory.)

RI(3) DM 840-6 & DM figure 840-11

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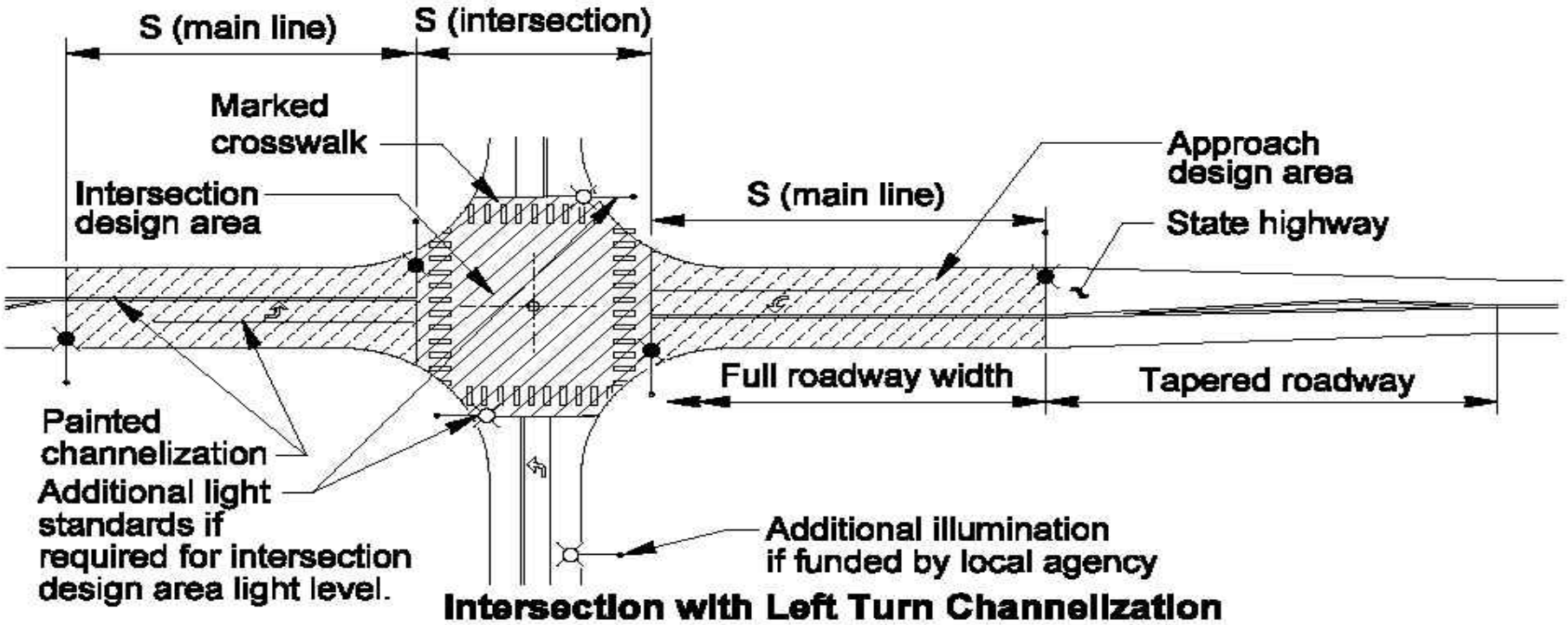
Intersections With Left Turn Channelization (4)



Intersection with Left Turn Channelization

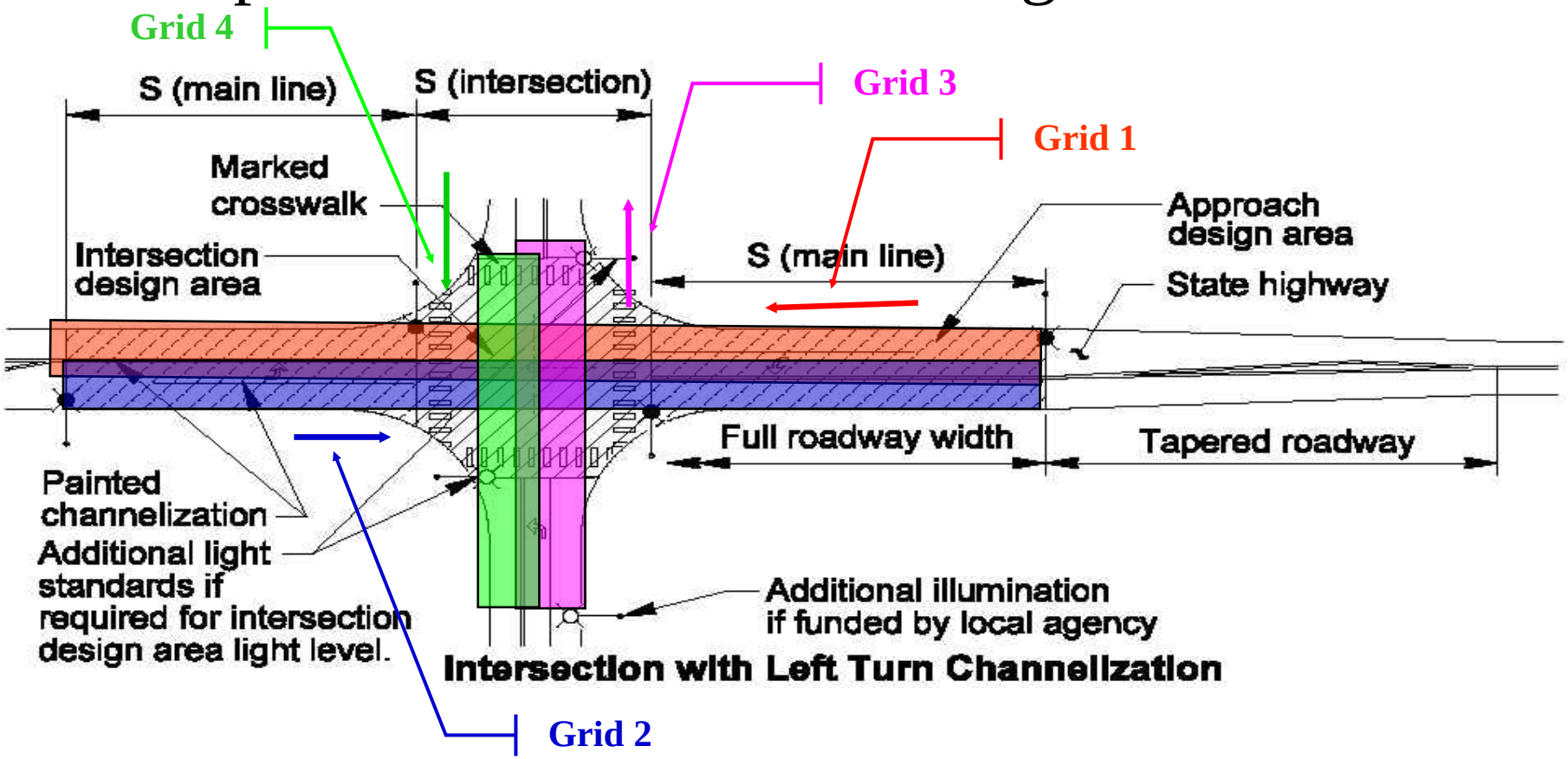
Legend

S Distance between light standards that will result in an average level that exceeds the requirements of Figure 840-6.

Light standard with mast arm mounted luminaire. (Locations are typical and not mandatory.)

RI(4) DM 840-2 & DM figure 840-13

How to place Luminance & Veiling Luminance Grids

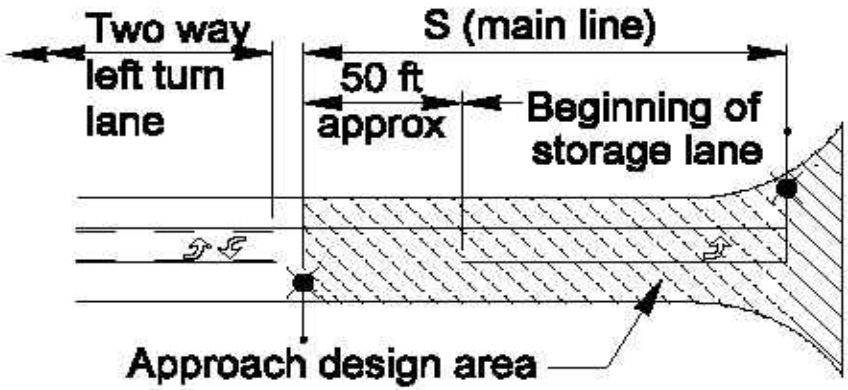


Legend

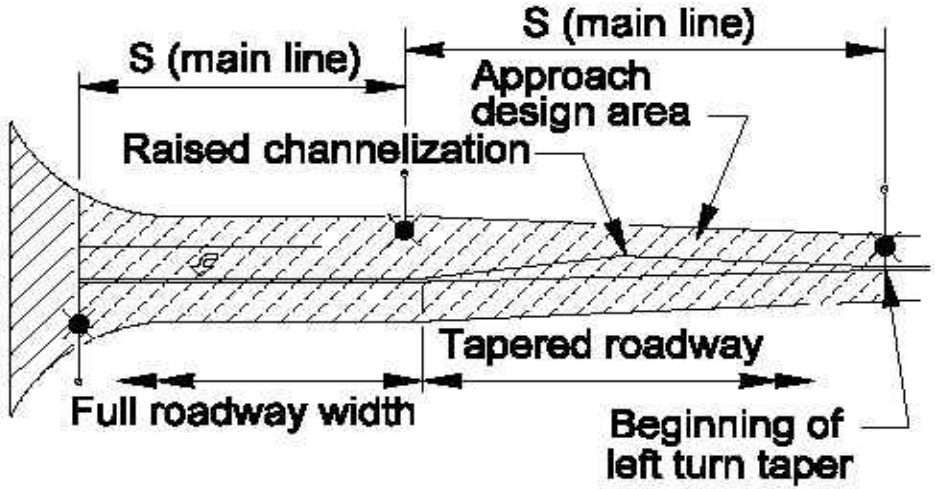
S Distance between light standards that will result in an average level that exceeds the requirements of Figure 840-6.

Light standard with mast arm mounted luminaire. (Locations are typical and not mandatory.)

Intersections With Left Turn Channelization (4)



Alternate for Transitions to Two Way Left Turn Lanes



Alternate for Raised Channelization

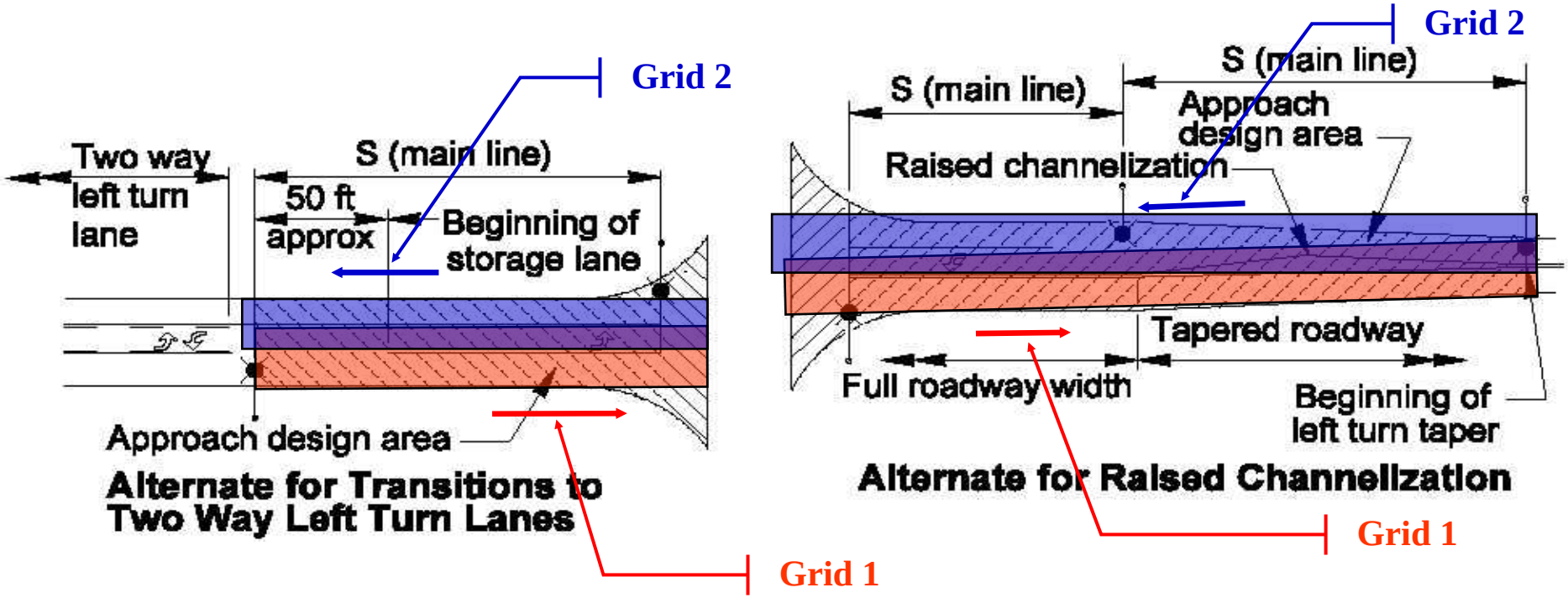
Legend

S Distance between light standards that will result in an average level that exceeds the requirements of Figure 840-6.

Light standard with mast arm mounted luminaire. (Locations are typical and not mandatory.)

RI (4) DM page 840-2 & DM figure 840-3

How to place Luminance & Veiling Luminance Grids



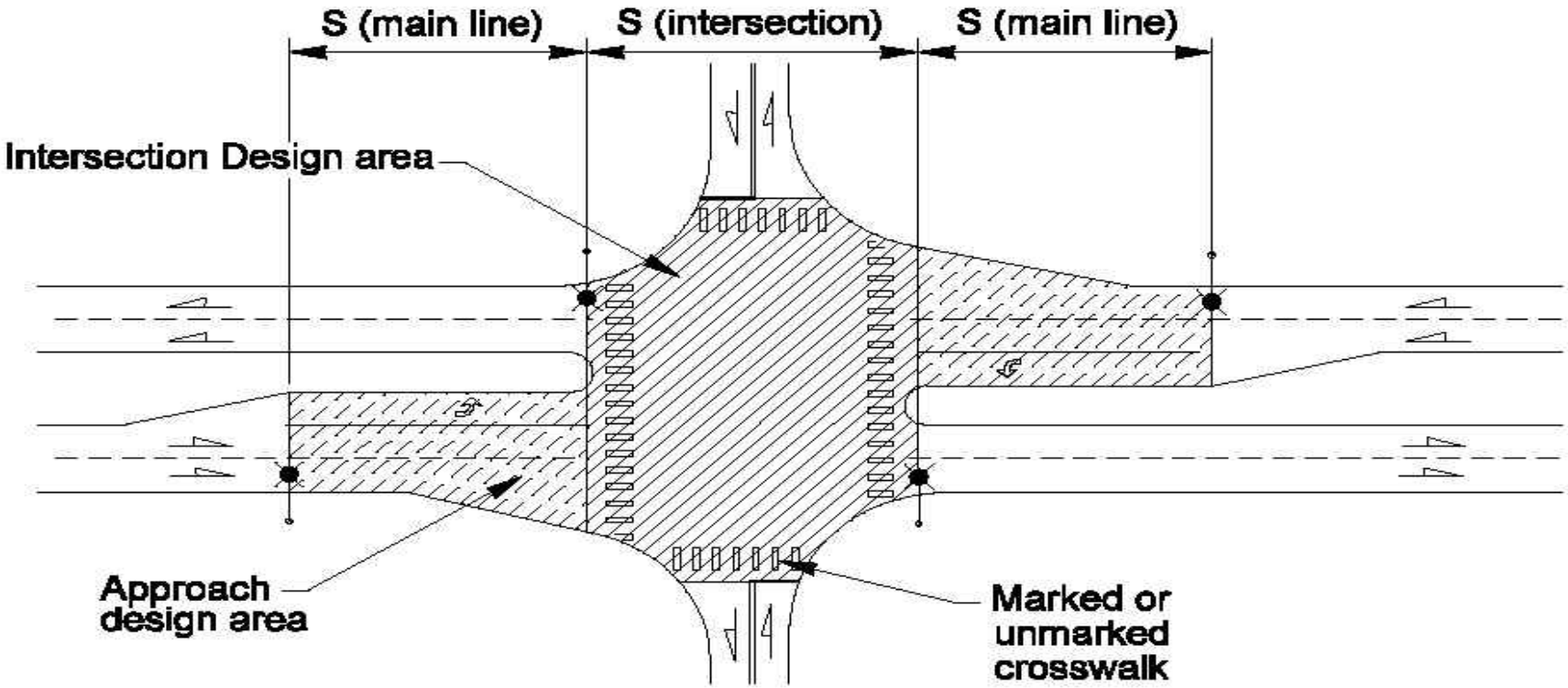
Legend

S Distance between light standards that will result in an average level that exceeds the requirements of Figure 840-6.

Light standard with mast arm mounted luminaire. (Locations are typical and not mandatory.)

RI(4) DM 840-2 & DM figure 840-3

Intersections With Left Turn Channelization (4)



Divided Highway Intersection

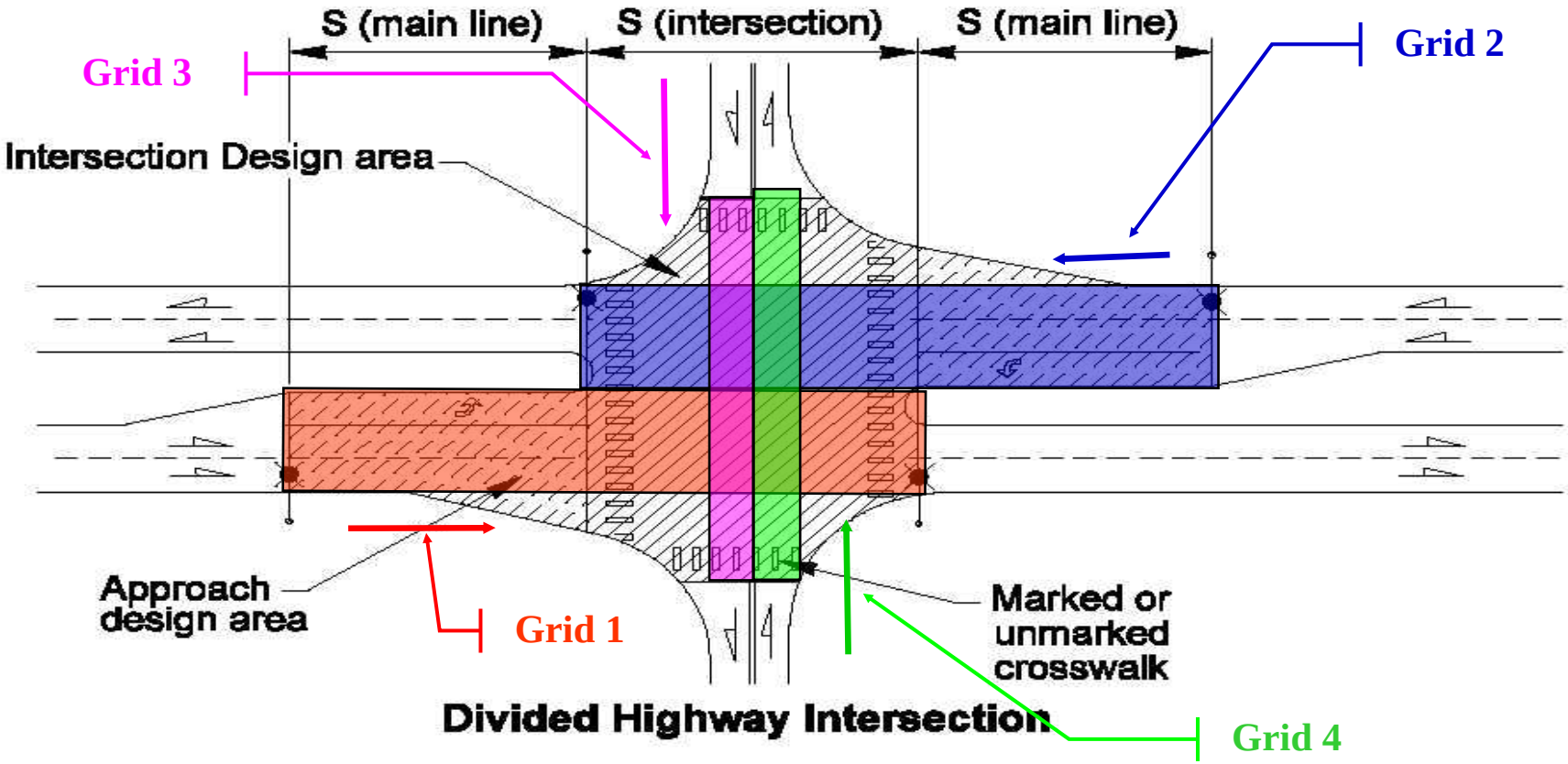
Legend

S Distance between light standards that will result in an average level that exceeds the requirements of Figure 840-6.

Light standard with mast arm mounted luminaire (Locations are typical and not mandatory.)

RI(4) DM 840-2 & figure DM 840-4

How to place Luminance & Veiling Luminance Grids

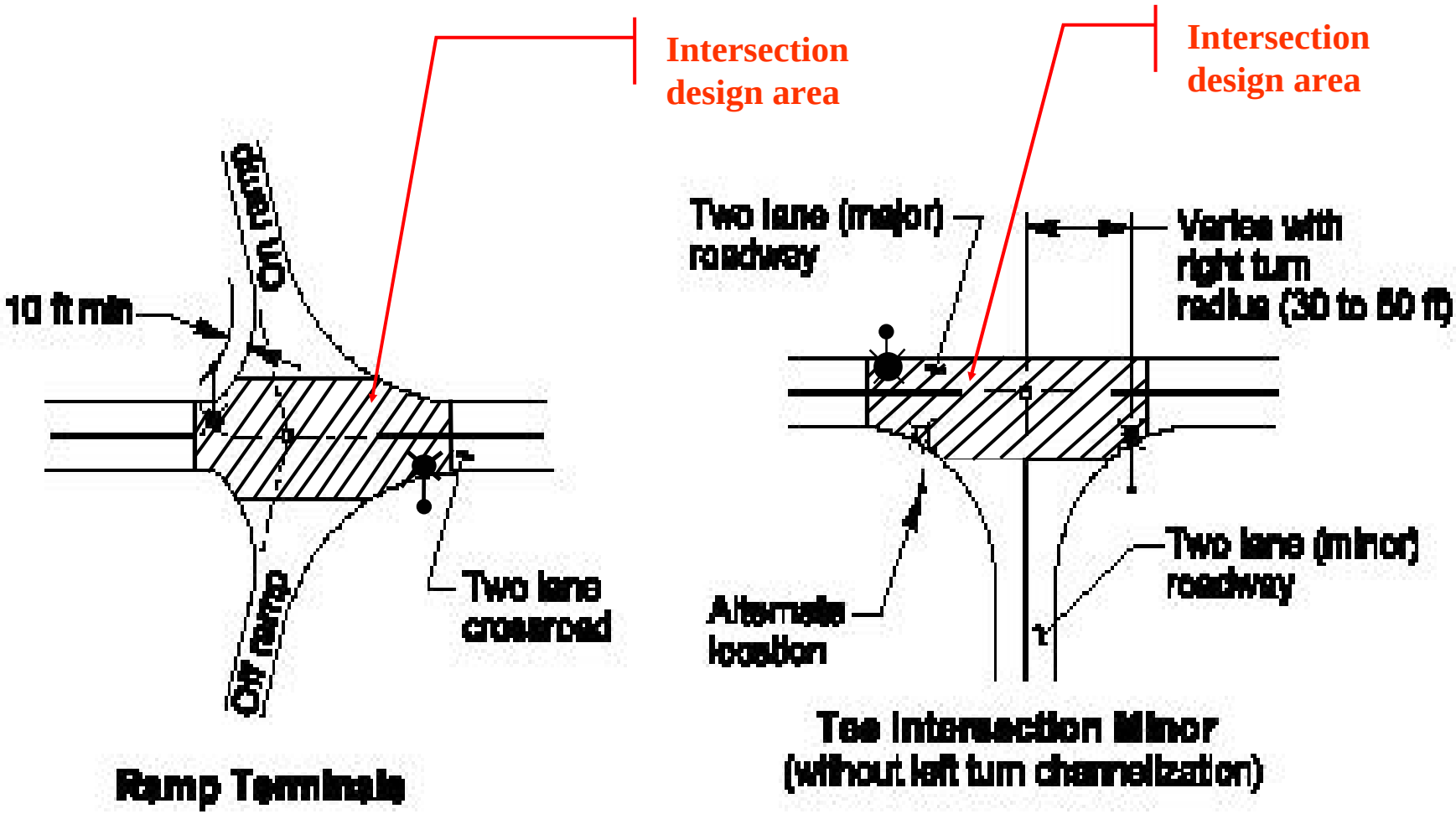


Legend

S Distance between light standards that will result in an average level that exceeds the requirements of Figure 840-6.

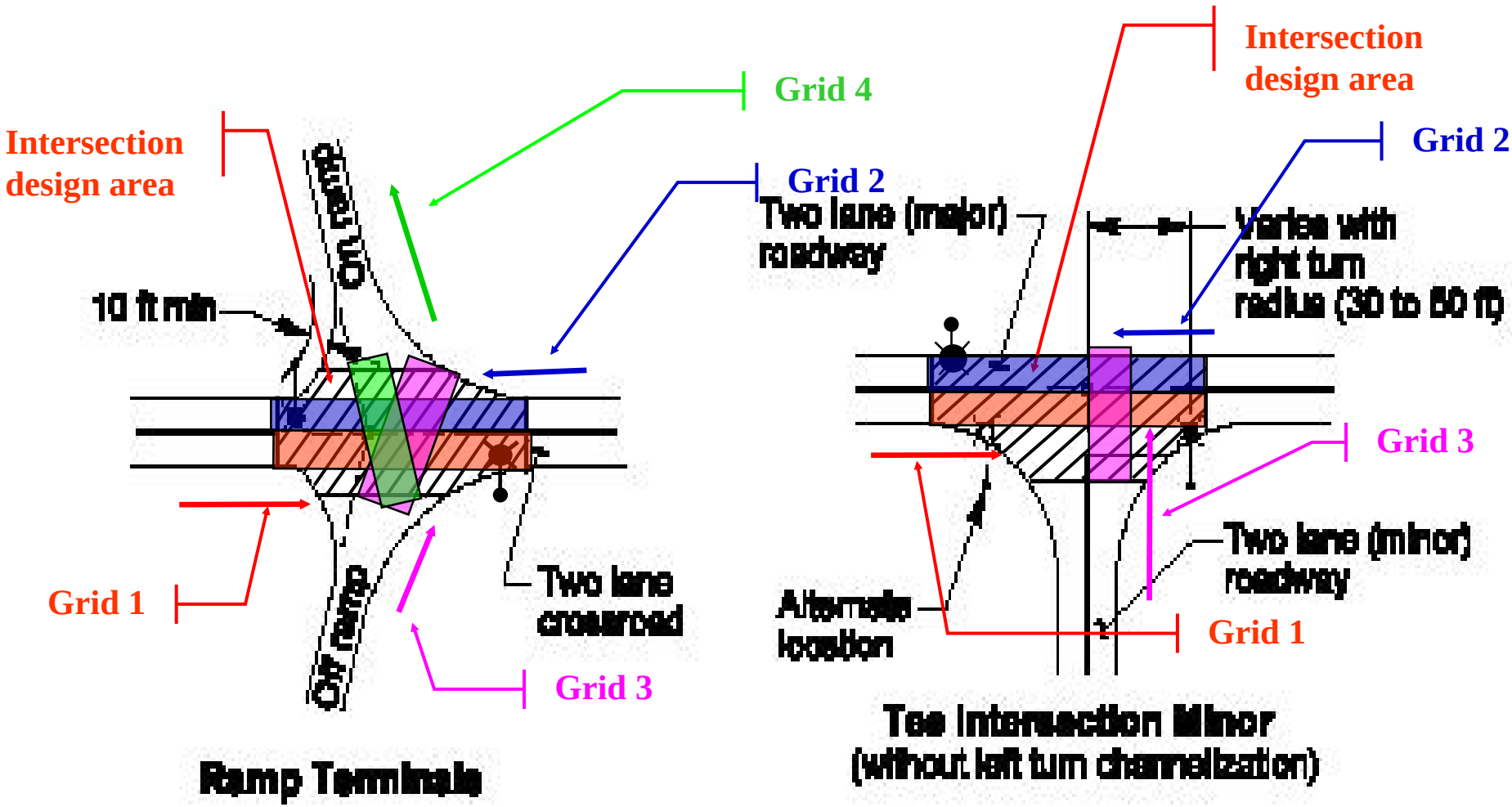
Light standard with mast arm mounted luminaire (Locations are typical and not mandatory.)

Intersections without channelization that have more than 1 luminaire

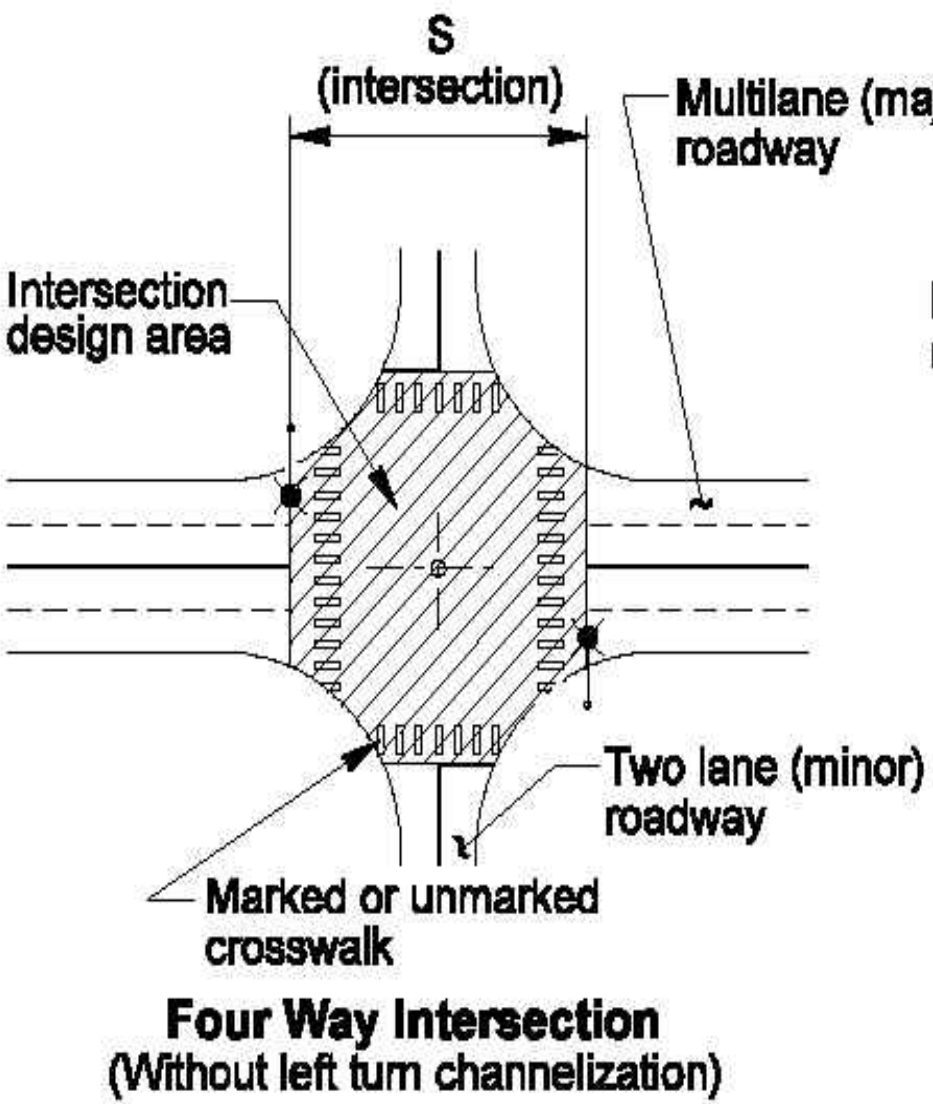


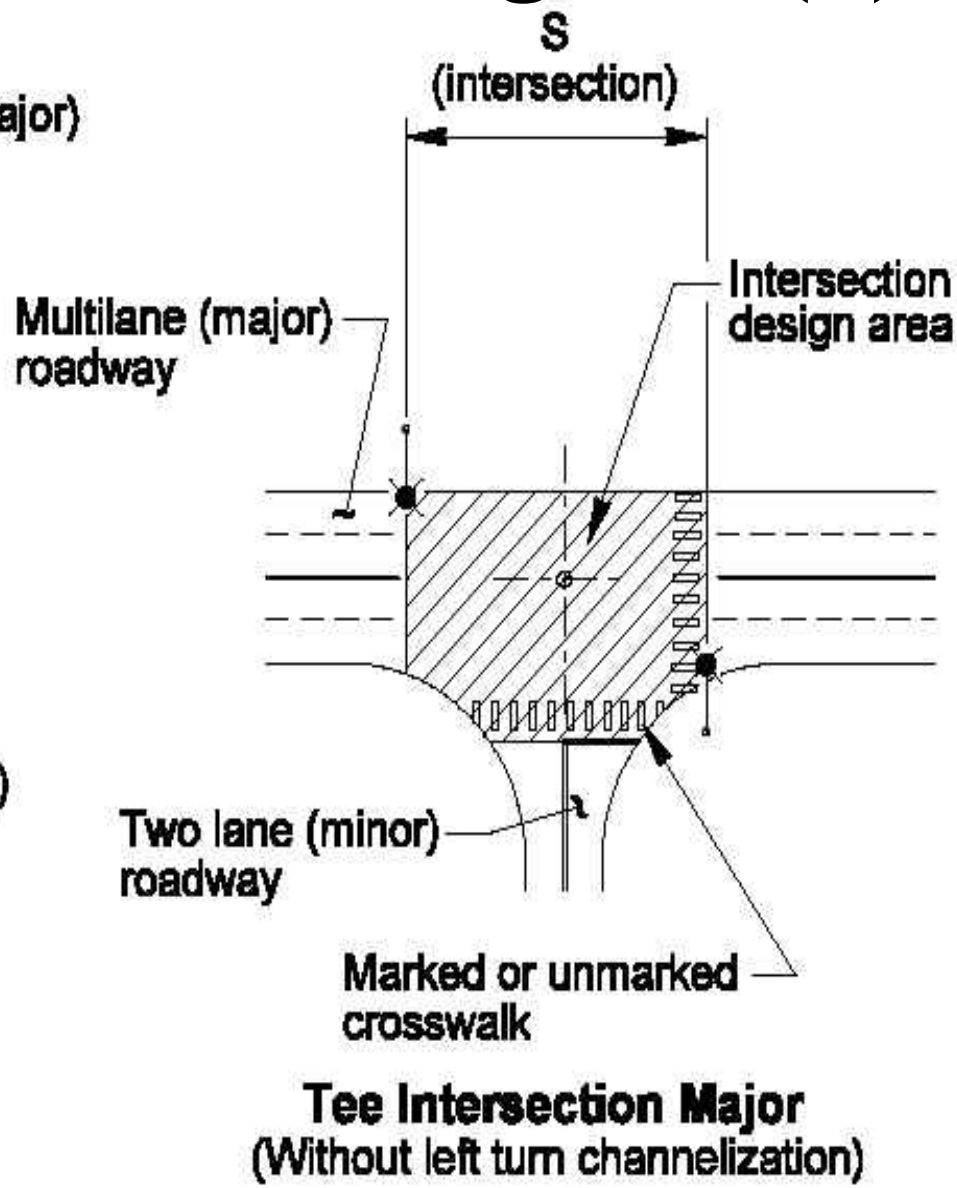
AI (4) DM 840-4 & Figure 840-4

How to place Luminance & Veiling Luminance Grids



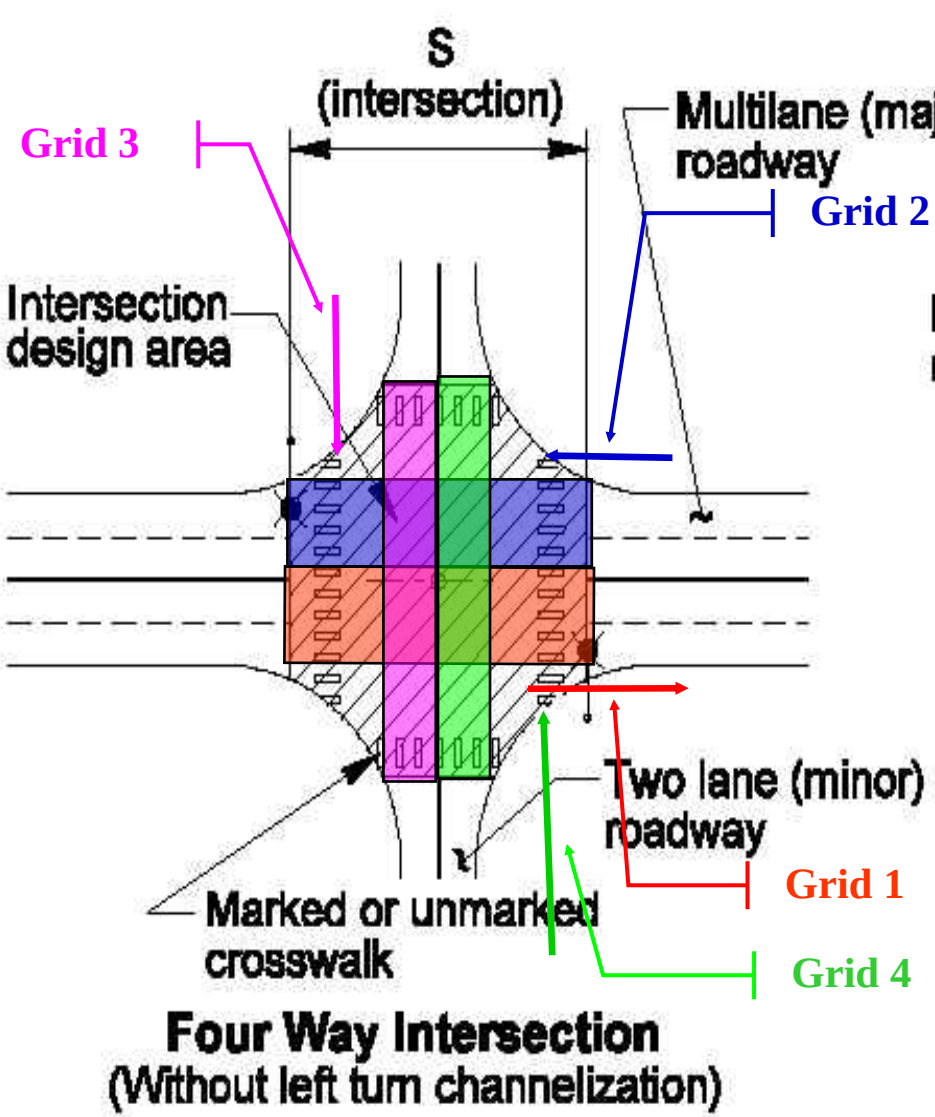
Intersections With Traffic Signals (5)

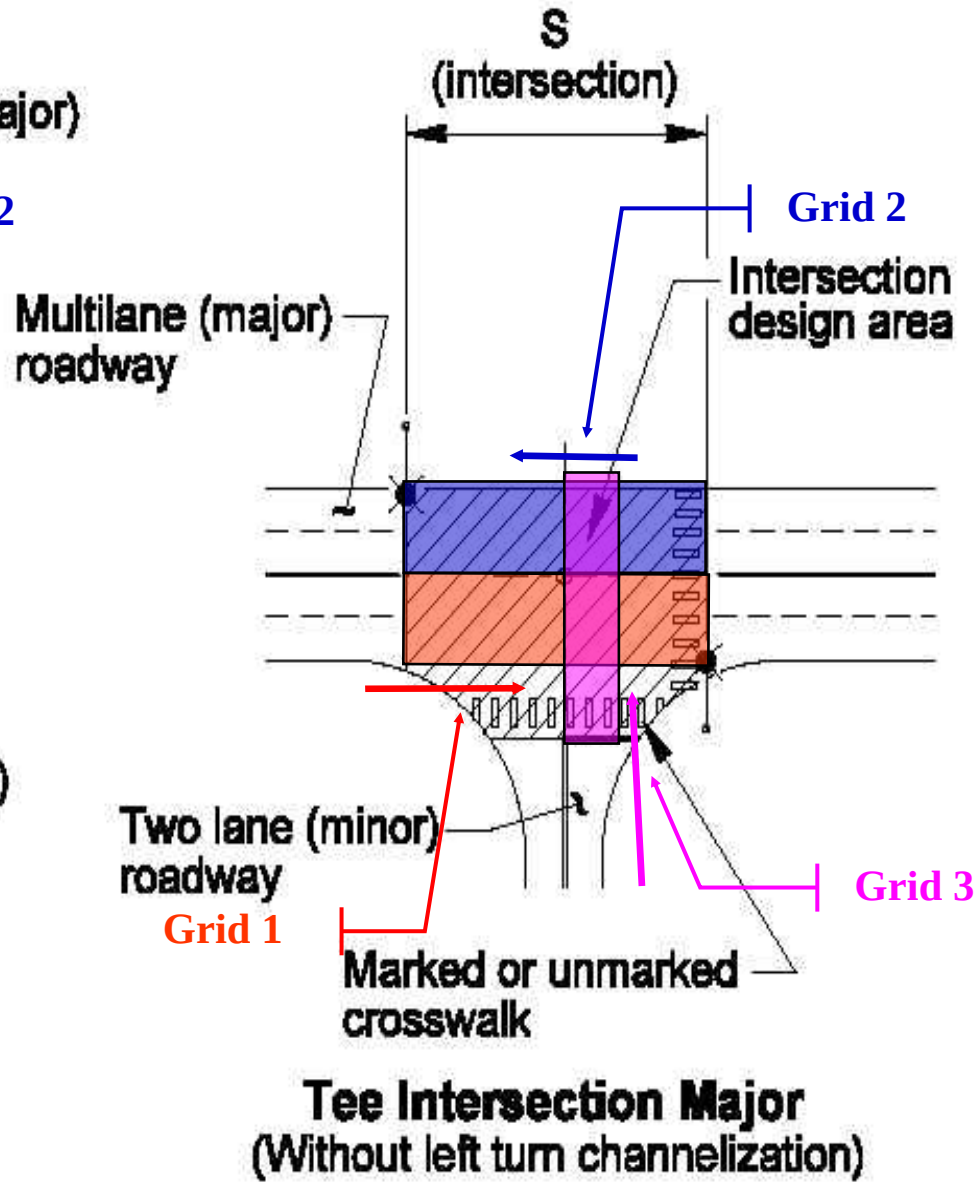




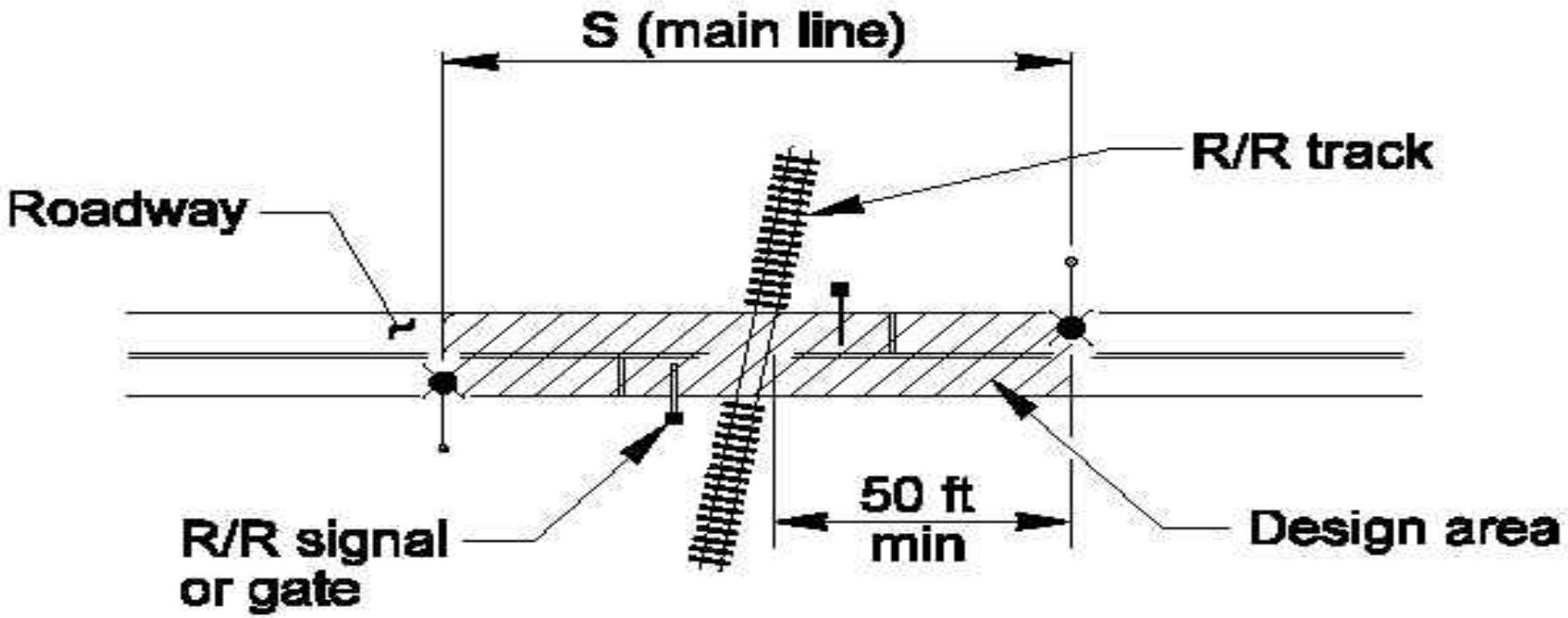
RI(5) DM 840-3 & figure DM 840-5

How to place Luminance & Veiling Luminance Grids





Railroad Crossings With Gates or Signals (6)



Railroad Crossing

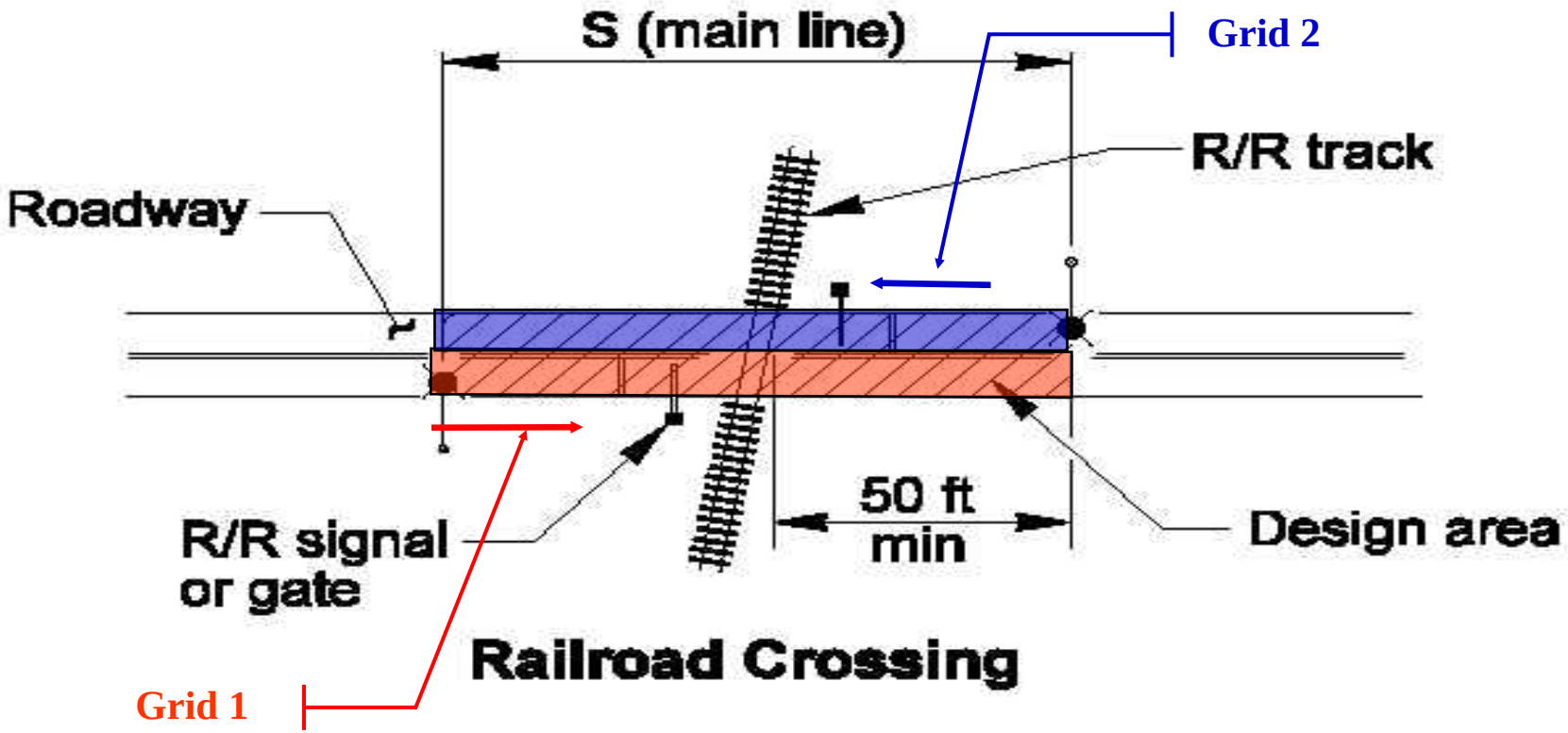
Legend

S Distance between light standards that will result in an average light level that exceeds the requirements of figure 840-6.

Light standard with mast arm mounted luminaire. (Locations are typical and not mandatory.)

RI(6) DM 840-3 & figure DM 840-5

How to place Luminance & Veiling Luminance Grids

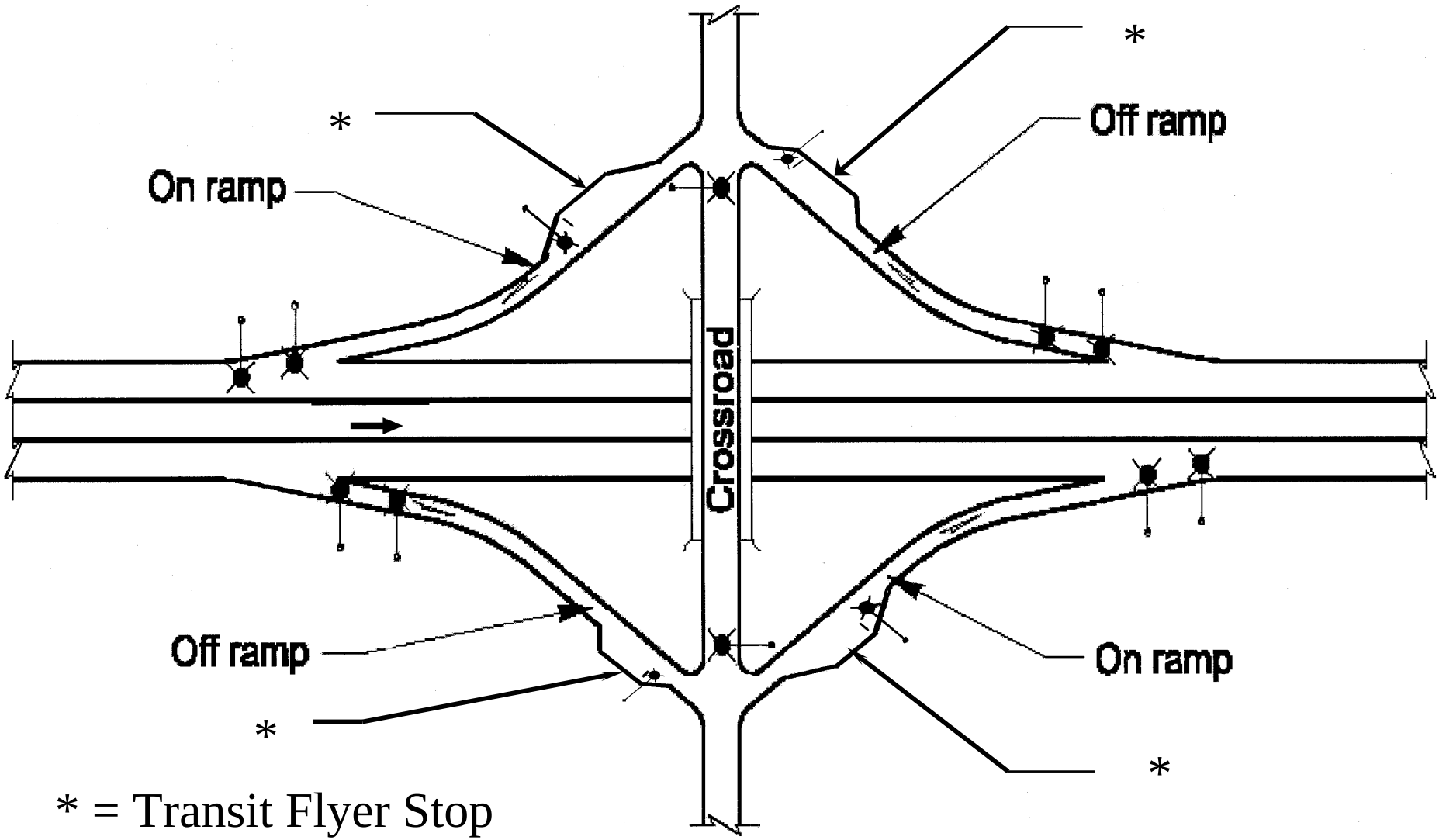


Legend

S Distance between light standards that will result in an average light level that exceeds the requirements of figure 840-6.

Light standard with mast arm mounted luminaire. (Locations are typical and not mandatory.)

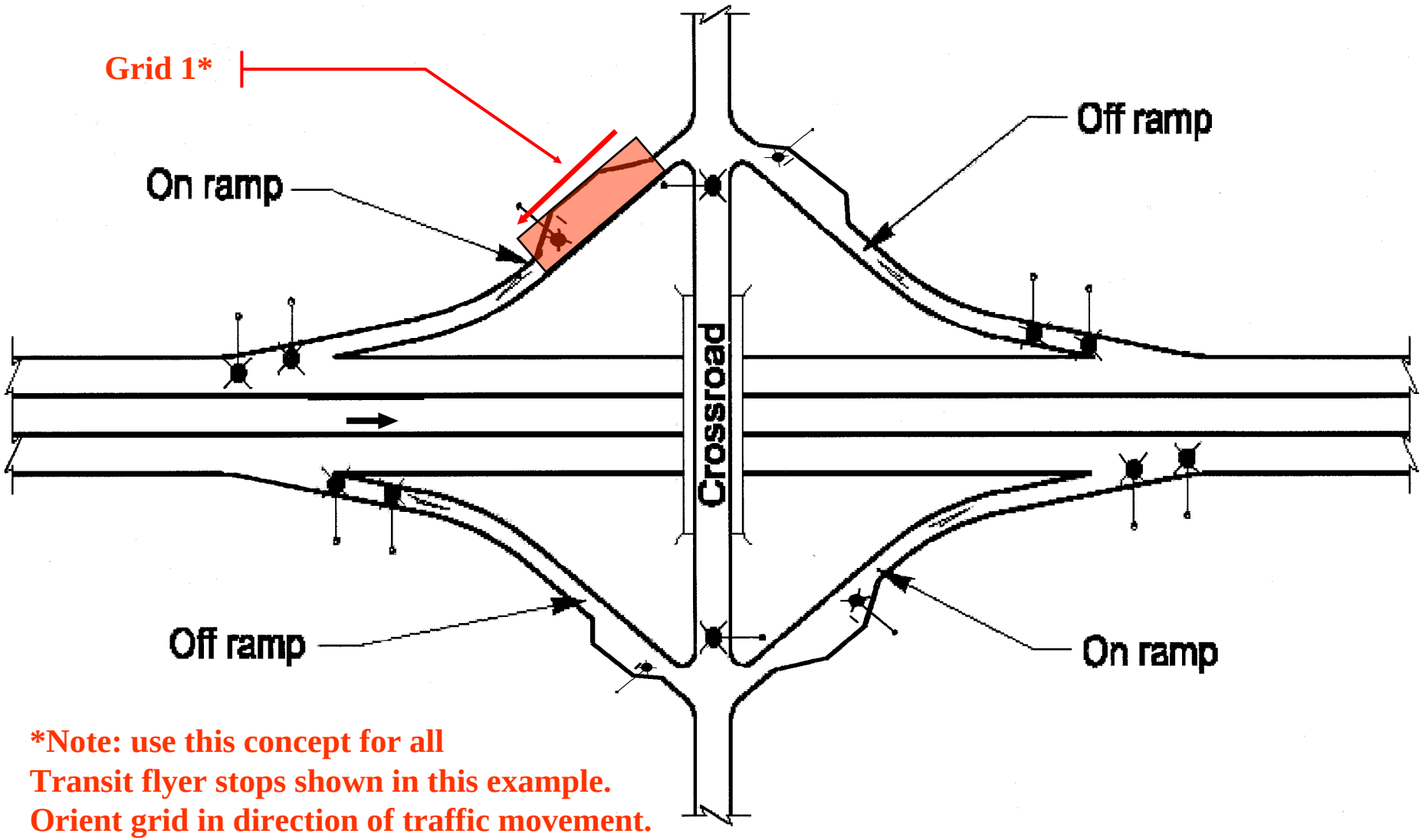
Transit Flyer Stop (7)



* = Transit Flyer Stop

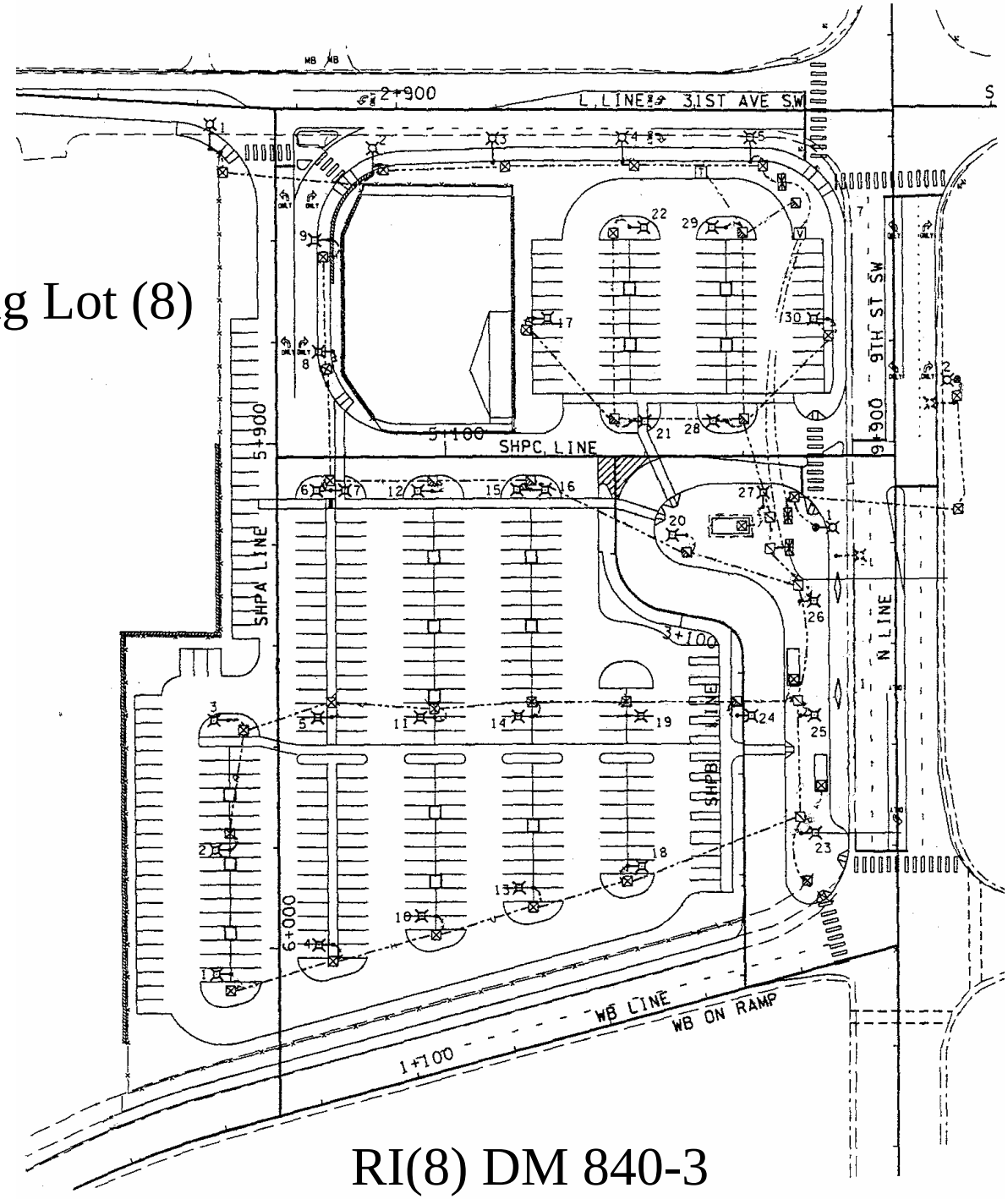
RI(7) DM 840-3 & figure DM 840-1, modified

How to place Luminance & Veiling Luminance Grids



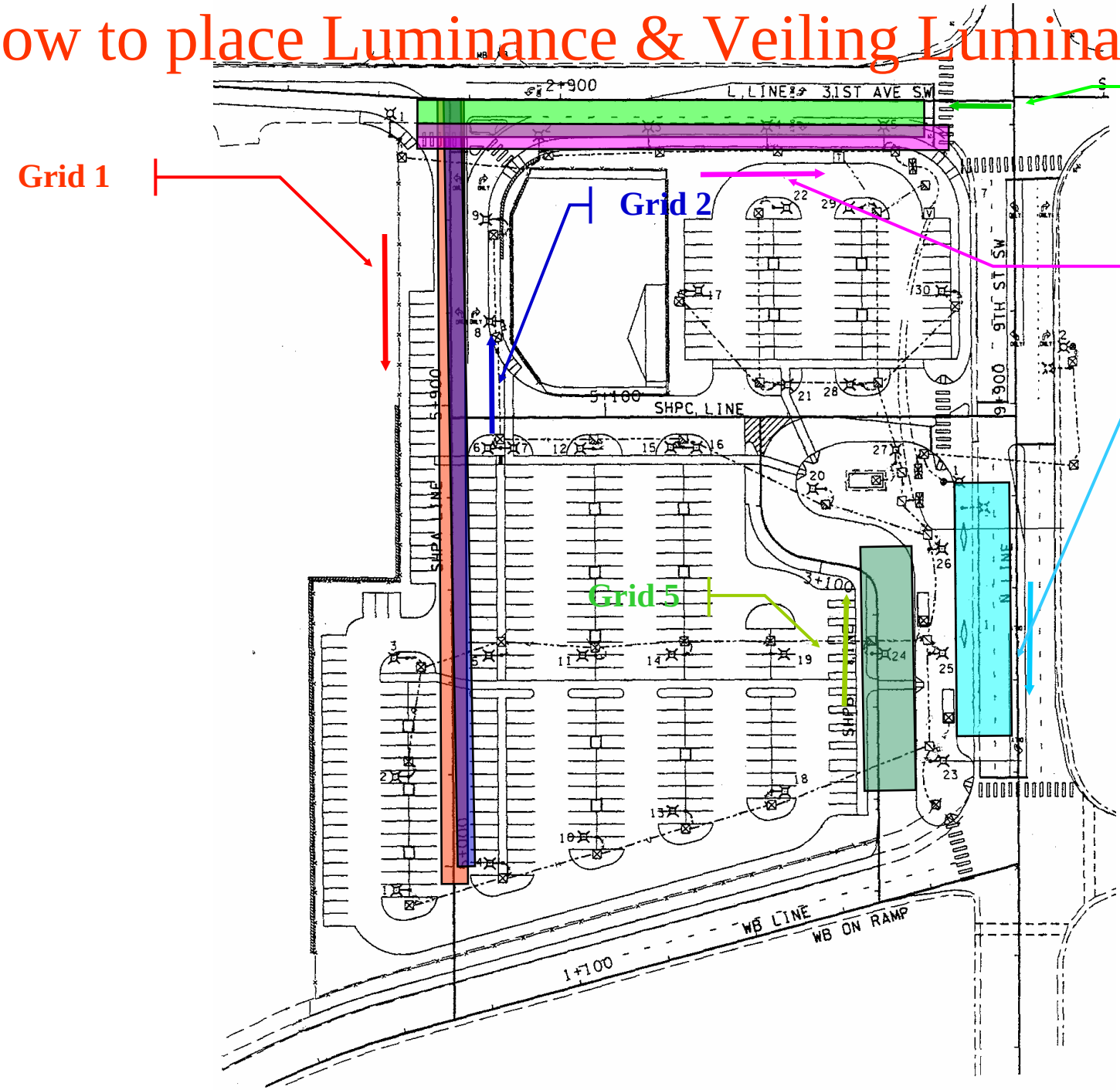
***Note: use this concept for all**
Transit flyer stops shown in this example.
Orient grid in direction of traffic movement.

Major Parking Lot (8)

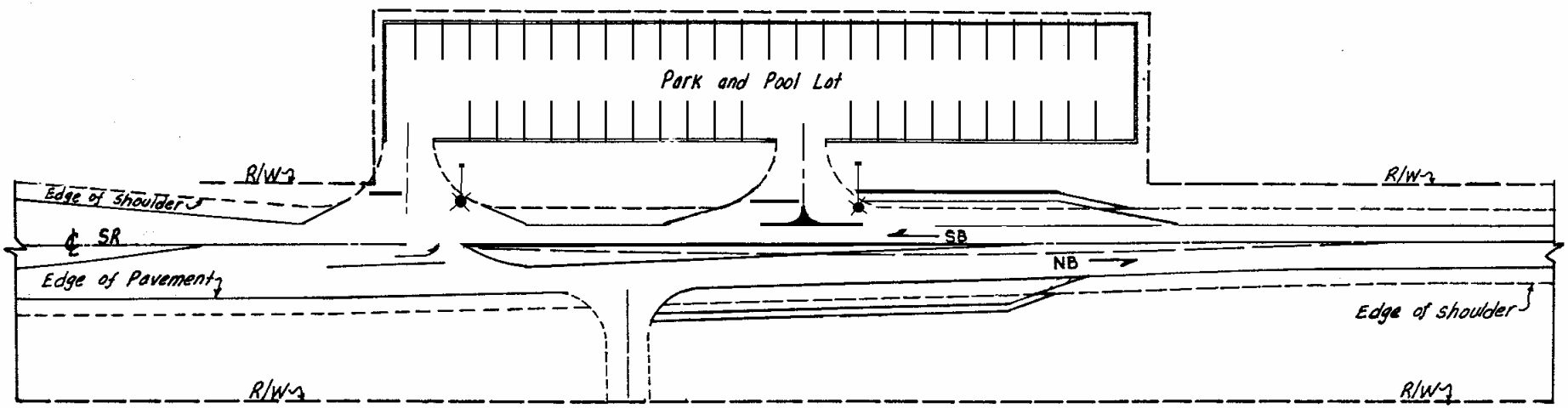


RI(8) DM 840-3

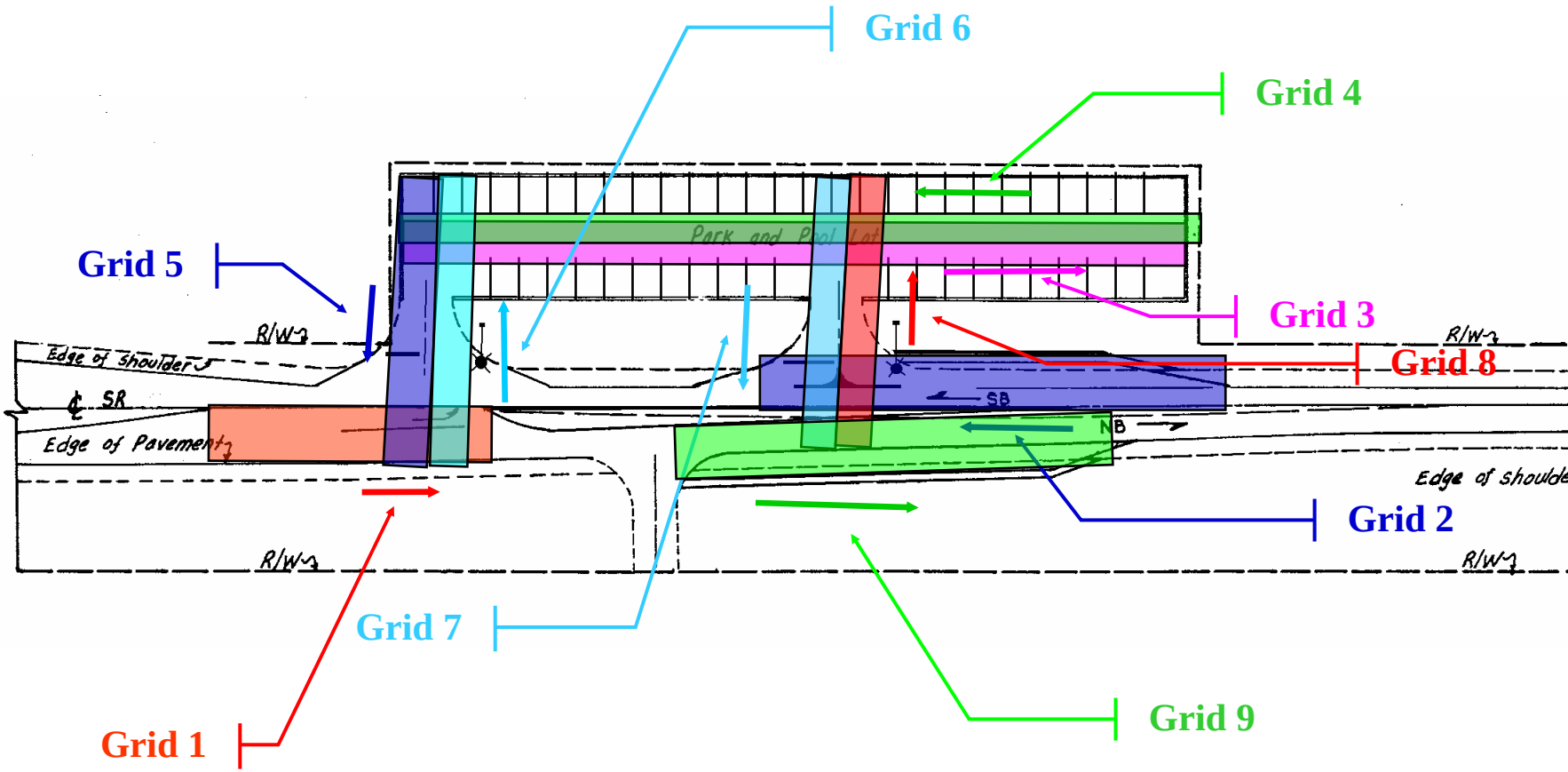
How to place Luminance & Veiling Luminance Grids



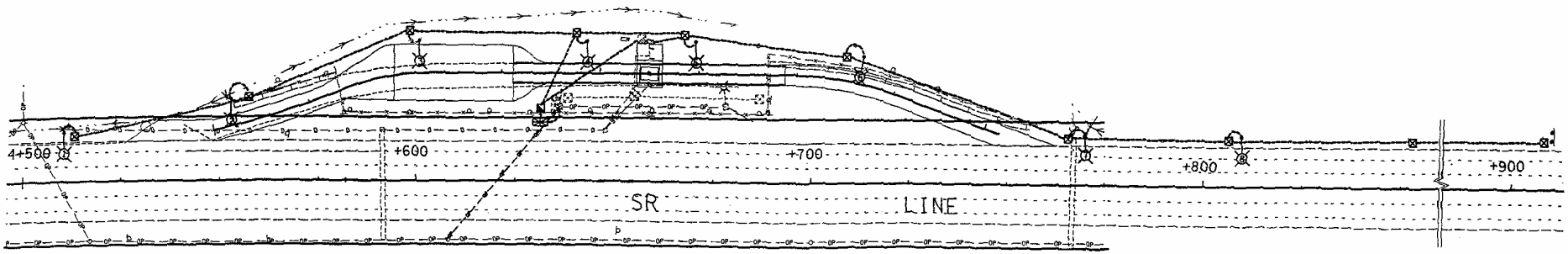
Minor Parking Lot (9)



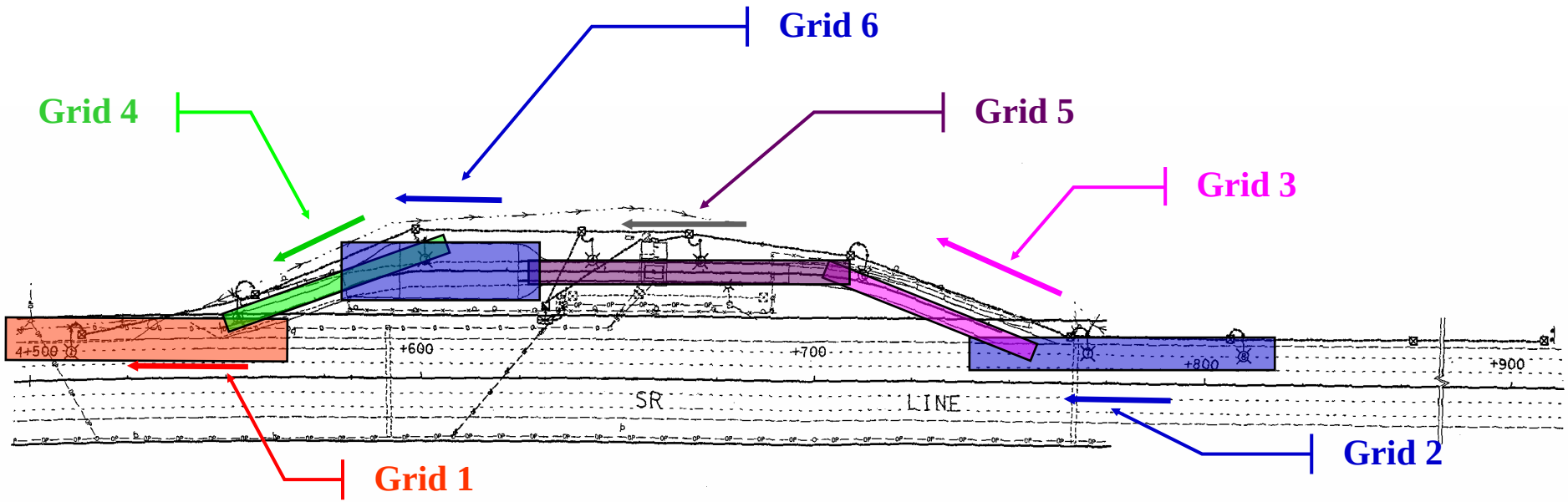
How to place Luminance & Veiling Luminance Grids



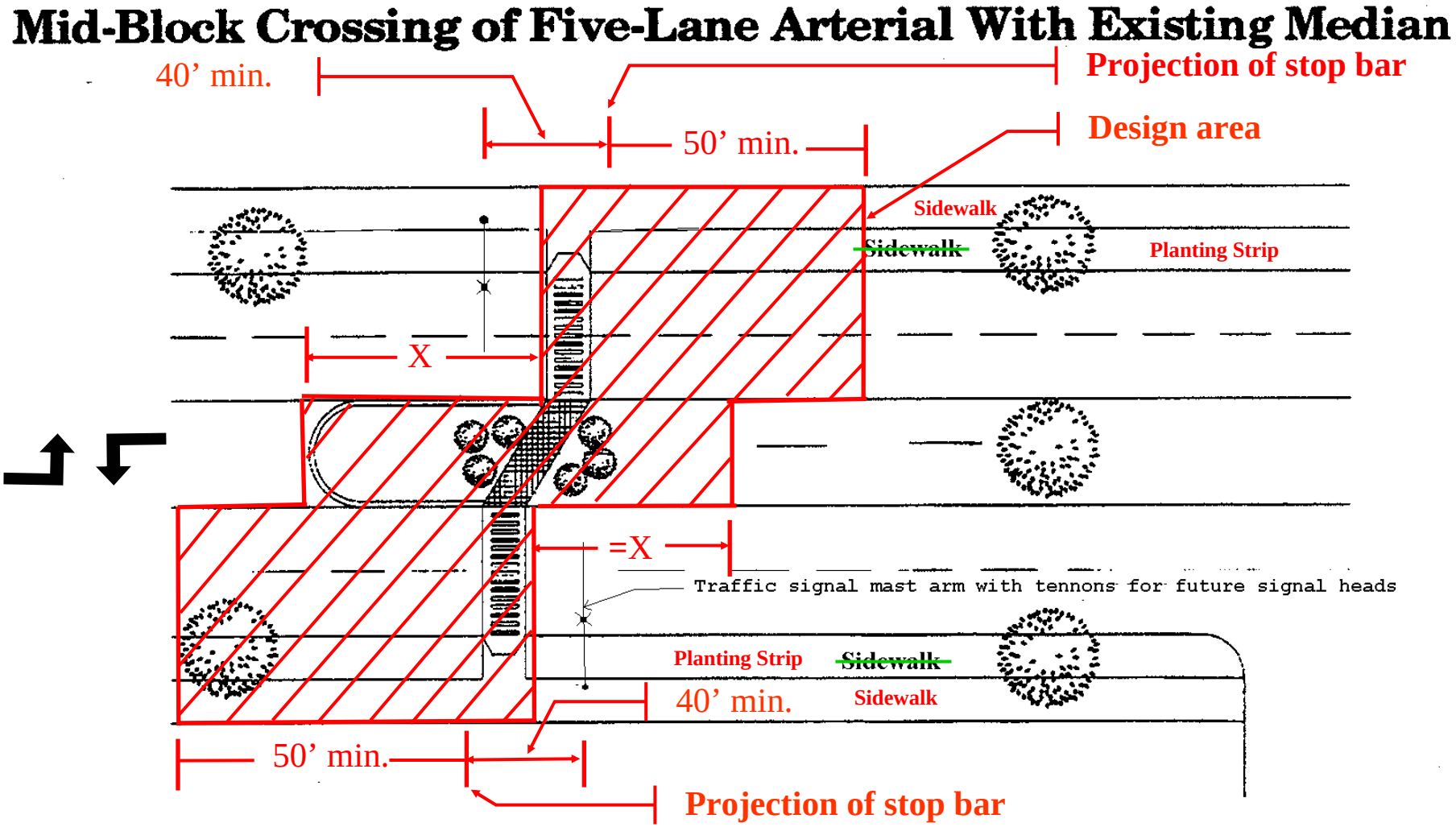
Truck Weigh Sites (10)



How to place Luminance & Veiling Luminance Grids

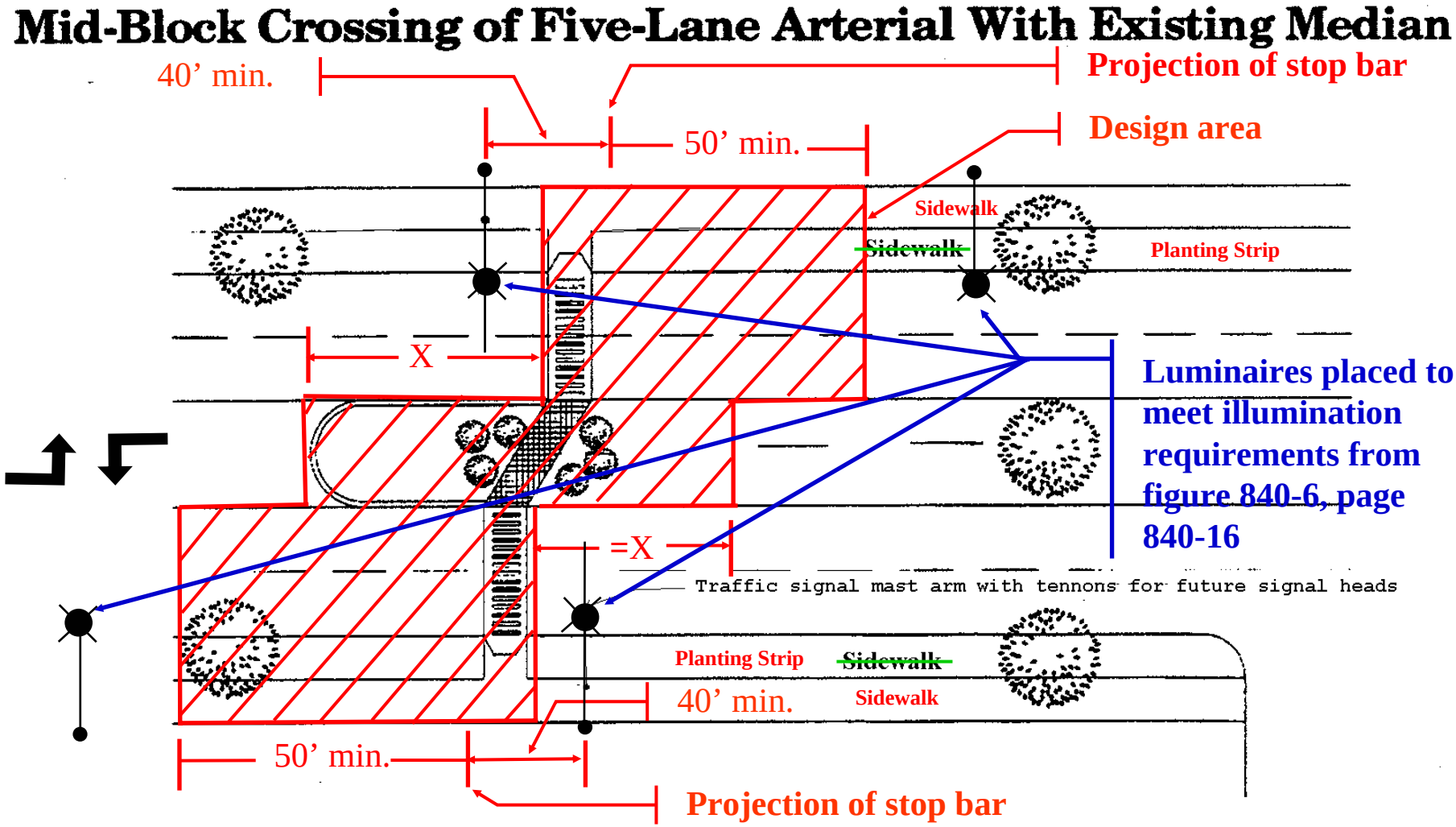


Midblock Pedestrian Crossing (11)



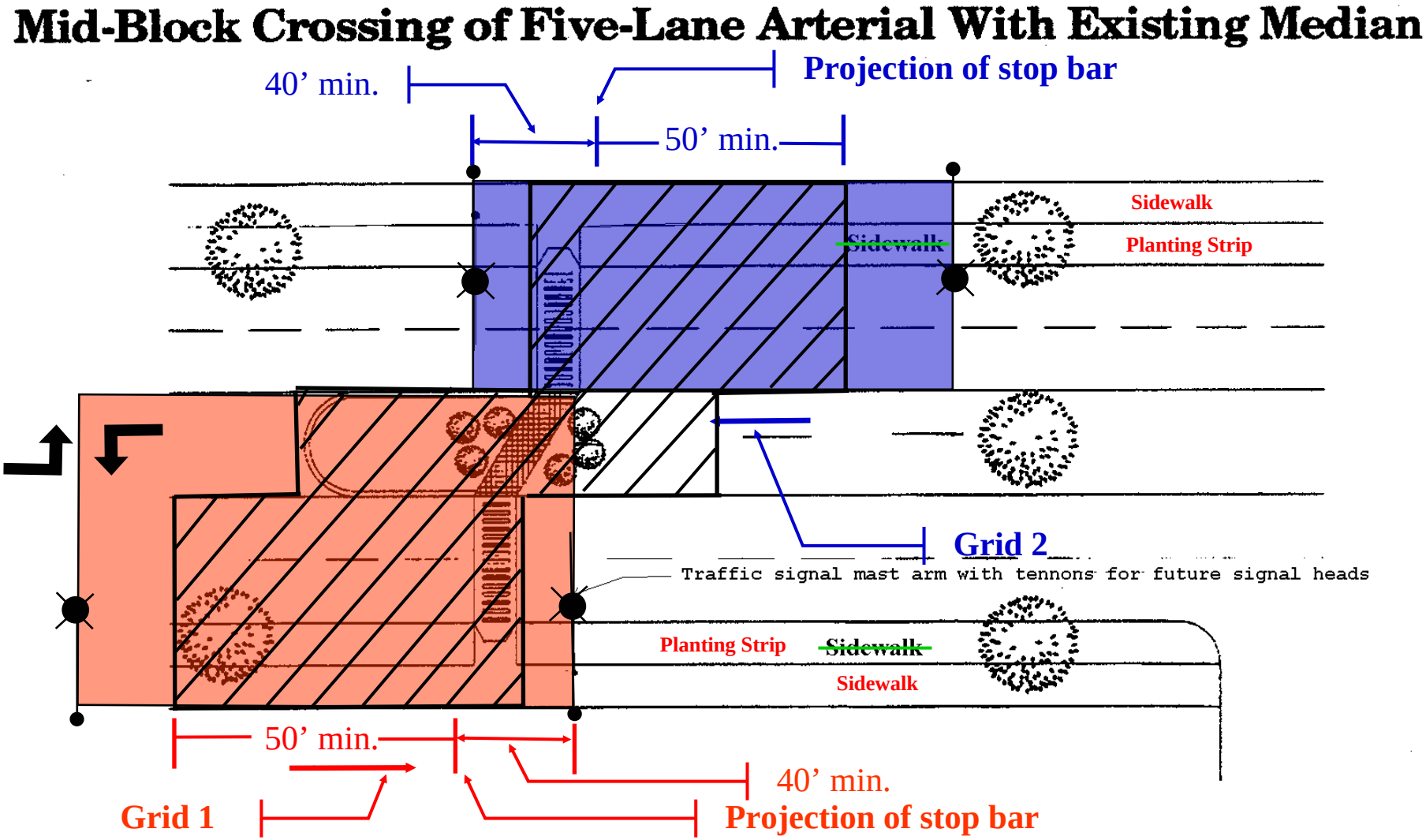
Design area encompasses midblock crossing with raised median pedestrian refuge, and the crossing is not within the limits of a continuously illuminated roadway.

Midblock Pedestrian Crossing (11)



Design area encompasses midblock crossing with raised median pedestrian refuge, and the crossing is not within the limits of a continuously illuminated roadway.

How to place Luminance & Veiling Luminance Grids



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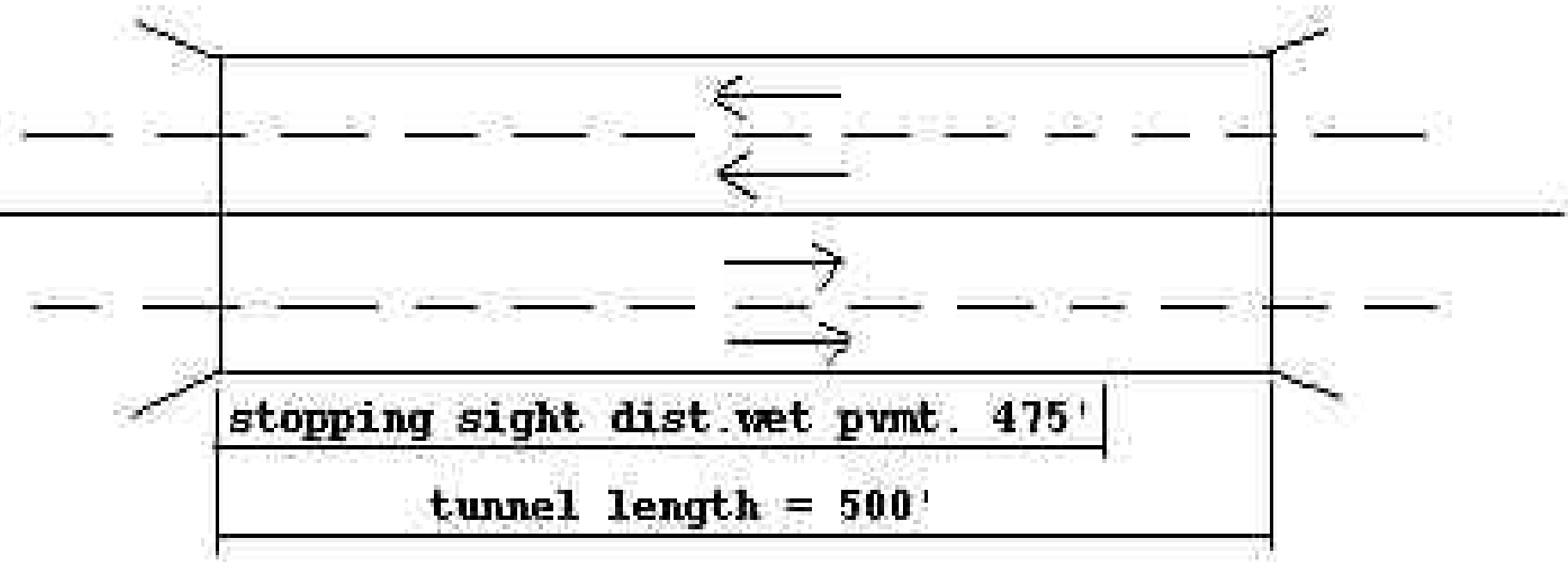
Long Tunnel (12)

Tunnel length=500'

Design speed=50mph

Wet pvmt. stopping sight distance=(44-50mph) 400'-475'



How to place Luminance & Veiling Luminance Grids

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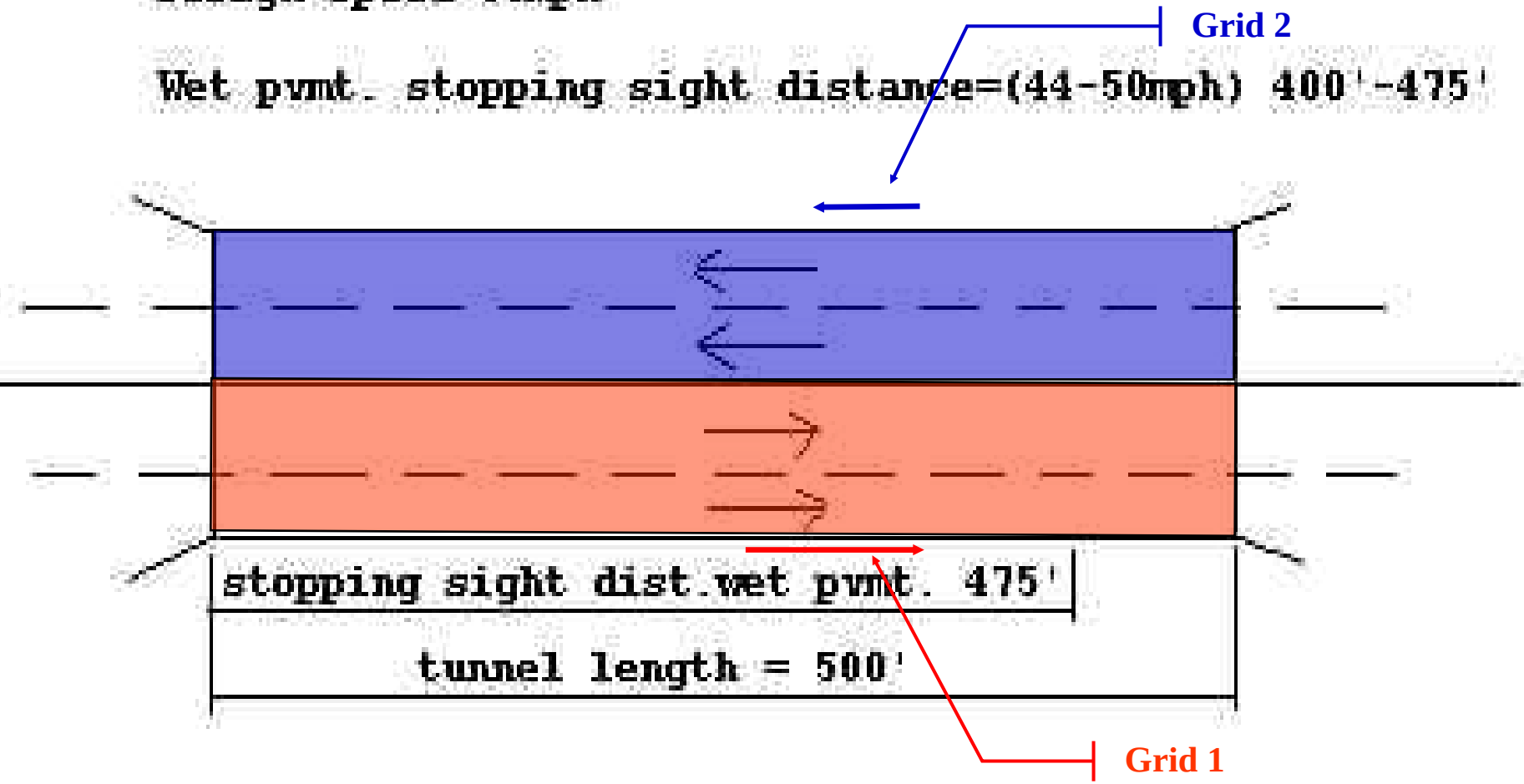


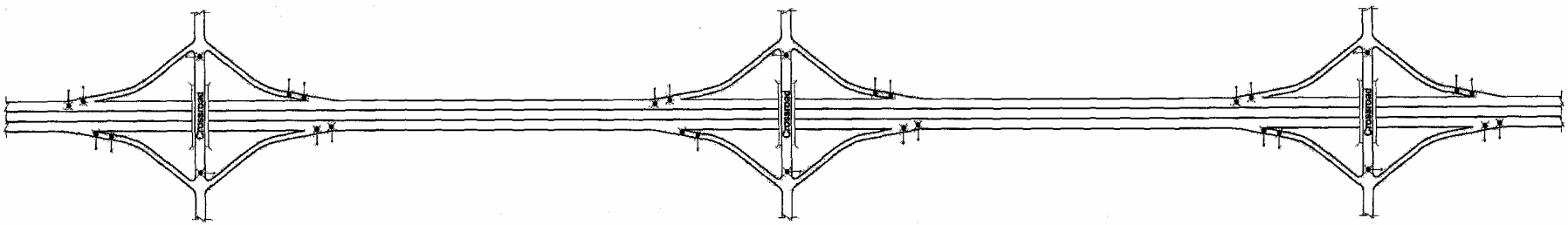
Additional Illumination (1)

- Diminished Level of Service
  - Mobility condition where the peak level of service is “D” or lower
- Accident Frequency
  - Condition when the number of nighttime accidents equal or exceed the number of daytime accidents
  - An Engineering study is needed to show that installing illumination will result in a reduction of nighttime accidents
- High nighttime pedestrian accident locations
  - AI 840-3

Additional Illumination (2)

- Highways With Full Access Control
  - Consider full illumination if a diminished level of service exists and any two of the following conditions exist:
    - There are three or more successive interchanges with an average spacing of 1 ½ miles or less.
    - The roadway section is in an urban area.
    - The accident frequency condition exists.
      - AI 840-4

Highways With Full Access Control (2)



Additional Illumination (2) cont.

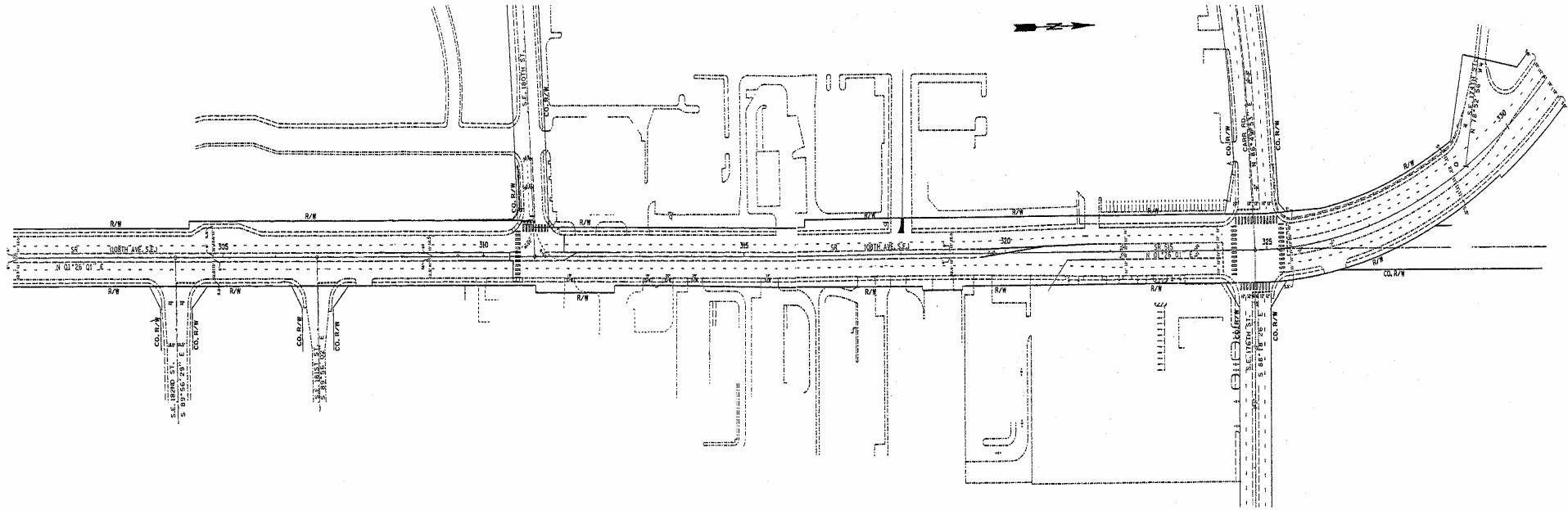
- Highways With Full Access Control
  - At ramps, consider additional illumination if a diminished level of service exists and any of the following conditions are present:
    - Complex ramp alignment & grade. **(suggested definition of "complex ramp alignment & grade" is a speed reduction of 35 mph from mainline speed or a 6% change in slope)**
    - Routine queues of five or more vehicles per lane at ramp terminal.
    - The nighttime accident frequency condition exists.
  - At crossroads, consider additional illumination when a diminished level of service exists and the nighttime accident frequency condition exists.
  - Also consider additional illumination for tunnels, under crossings, or lids on the crossroads.

AI(2)
DM 840-4


GAS NEXT RIGHT
76

Additional Illumination (3)

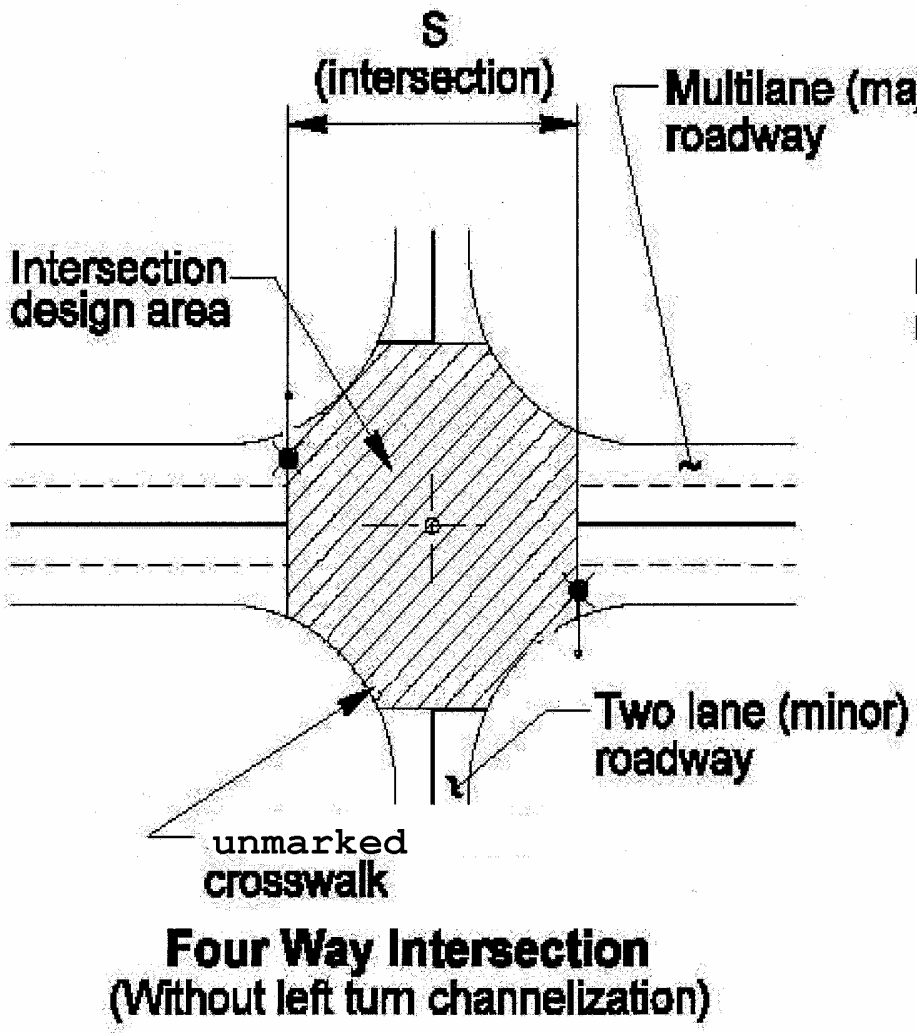
- Highways With Partial or Modified Limited Access Control or With Managed Access Control
  - Consider additional illumination if the highway segment is in a commercial area and;
  - A diminished level of service exists.
  - Or the nighttime accident frequency condition exists and an engineering study indicates the nighttime driving condition would be improved.


R/W
CO. R/W
305
310
315
320
325
330

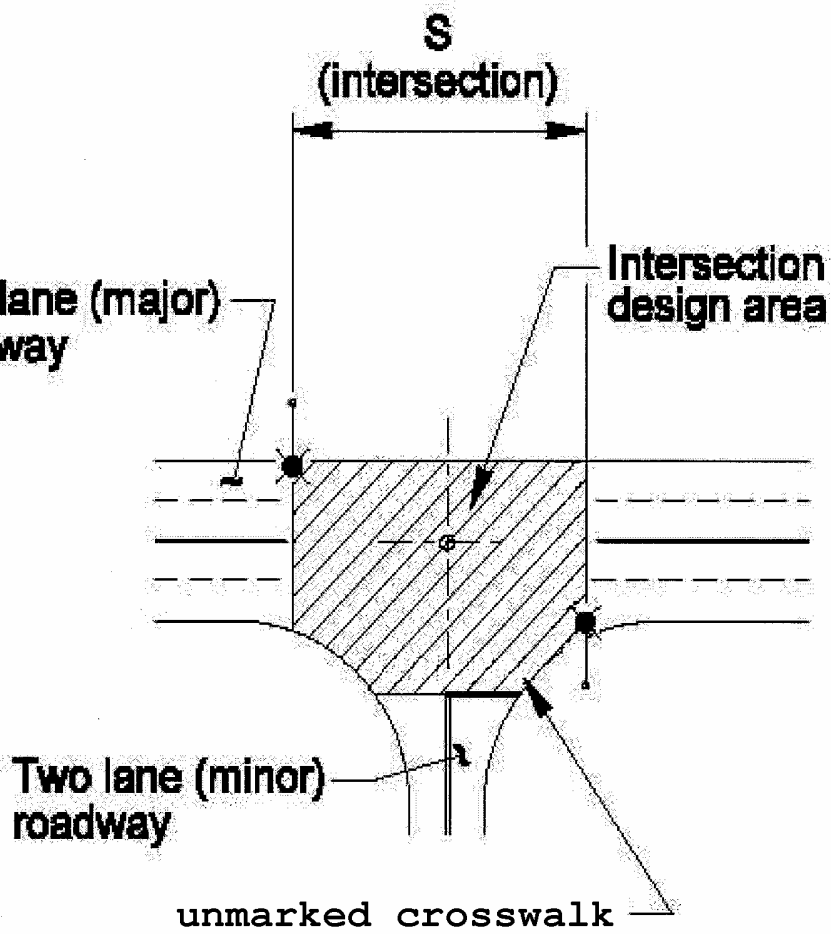
Additional Illumination (4)

- Intersections Without Channelization
  - Illumination of an intersection without channelization is justified if:
    - The intersection is located in an urban area.
    - The intersection is located outside the urban area and a nighttime accident frequency condition exists.
    - Traffic volumes would be improved with the installation of left turn channelization.

Intersections Without Channelization or Signals (4)



Four Way Intersection
(Without left turn channelization)



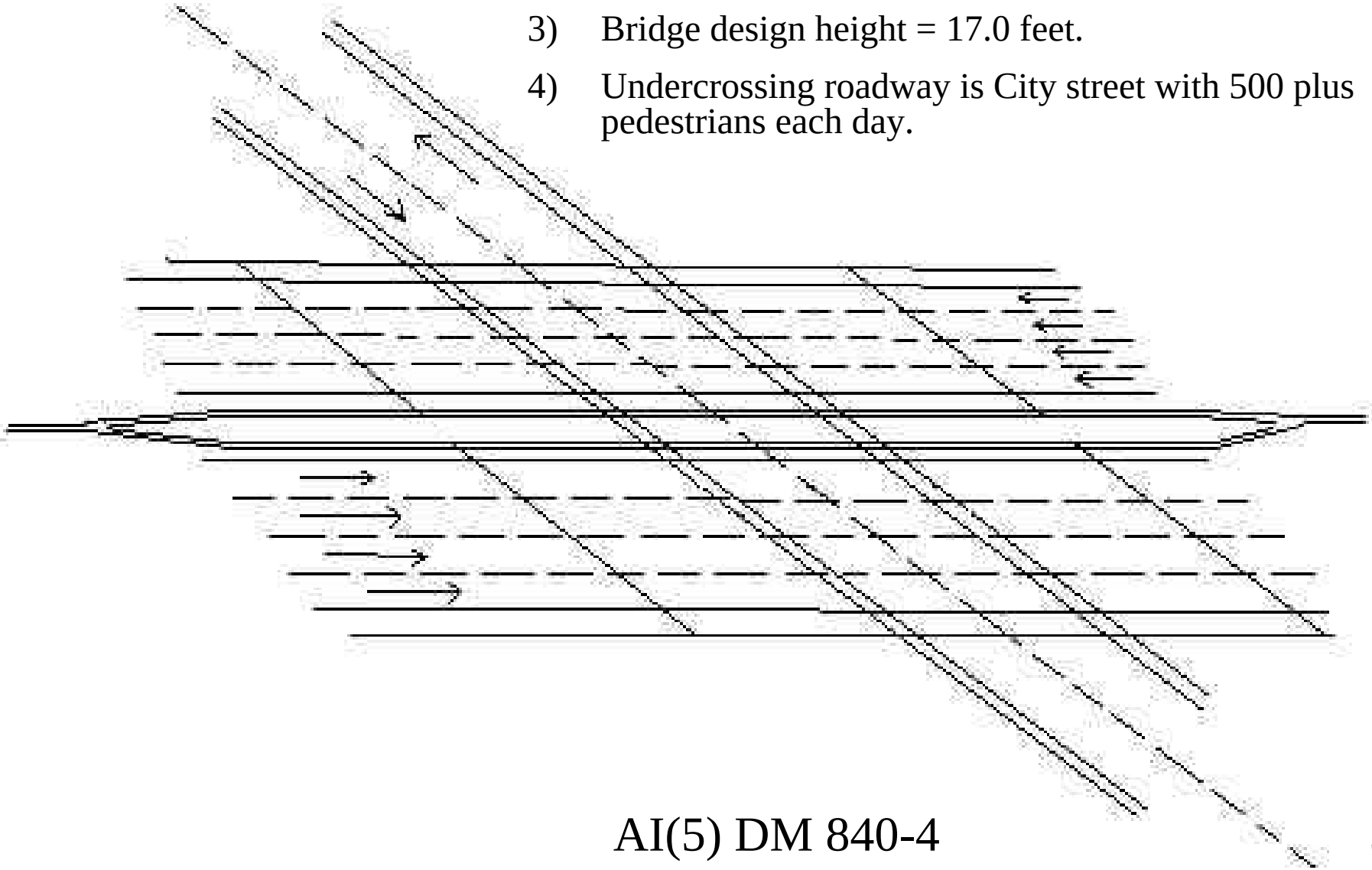
Tee Intersection Major
(Without left turn channelization)

Additional Illumination (5)

- Tunnels, Underpasses or Lids
  - Illumination is justified if:
    - portal conditions result in a brightness in the tunnel that is less than the measured daytime brightness of the approach roadway divided by 15 and,
    - The length to vertical clearance ratio is 10:1 or greater.

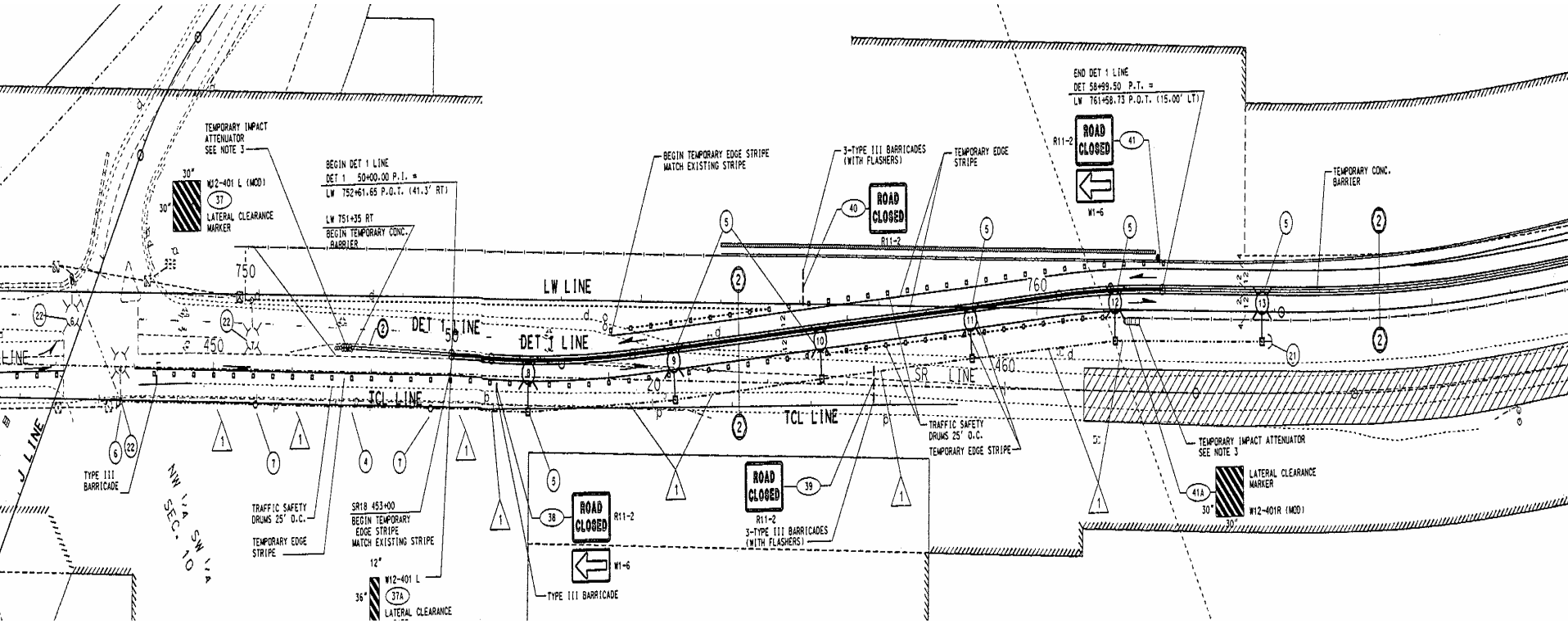
Given:

1) Widen three lane roadway to four lane roadway.
2) Gap between new traffic barrier on structures is 4 feet.
3) Bridge design height = 17.0 feet.
4) Undercrossing roadway is City street with 500 plus pedestrians each day.



Additional Illumination (6)

- Construction Zones and Detours
  - Illumination may be justified if:
    - Construction activities occur on roadway at night.
    - The alignment and grade are unusual and require additional driver, cyclist or pedestrian alertness.


TEMPORARY IMPACT ATTENUATOR SEE NOTE 3
W12-401 L (MOD)
LATERAL CLEARANCE MARKER
BEGIN DET 1 LINE
DET 1 50+00.00 P.I. =
LW 752+61.65 P.O.T. (41.3' RT)
LW 751+35 RT
BEGIN TEMPORARY CONC. BARRIER
BEGIN TEMPORARY EDGE STRIPE MATCH EXISTING STRIPE
3-TYPE III BARRICADES (WITH FLASHERS)
TEMPORARY EDGE STRIPE
ROAD CLOSED
R11-2
END DET 1 LINE
DET 58+99.50 P.T. =
LW 761+58.73 P.O.T. (15.00' LT)
W1-6
TEMPORARY CONC. BARRIER
LW LINE
DET 1 LINE
DET J LINE
TCL LINE
SR LINE
TYPE III BARRICADE
TRAFFIC SAFETY DRUMS 25' O.C.
TEMPORARY EDGE STRIPE
SR18 453+00
BEGIN TEMPORARY EDGE STRIPE MATCH EXISTING STRIPE
W12-401 L
LATERAL CLEARANCE
TYPE III BARRICADE
TRAFFIC SAFETY DRUMS 25' O.C.
TEMPORARY EDGE STRIPE
3-TYPE III BARRICADES (WITH FLASHERS)
TEMPORARY IMPACT ATTENUATOR SEE NOTE 3
LATERAL CLEARANCE MARKER
W12-401R (MOD)
NW 1/4 SW 1/4 SEC. 10
750
760
450
460

Additional Illumination (7)

- Transit Stops
  - Transit stops with shelters are indicative of higher passenger usage and illumination is justified. This lighting consists of one luminaire positioned to illuminate both the transit pull out area and the loading area.
  - Additional illumination to further illuminate the loading area at transit stops with significant, nighttime activity may be considered, if the transit agency will provide the funding for construction and maintenance.

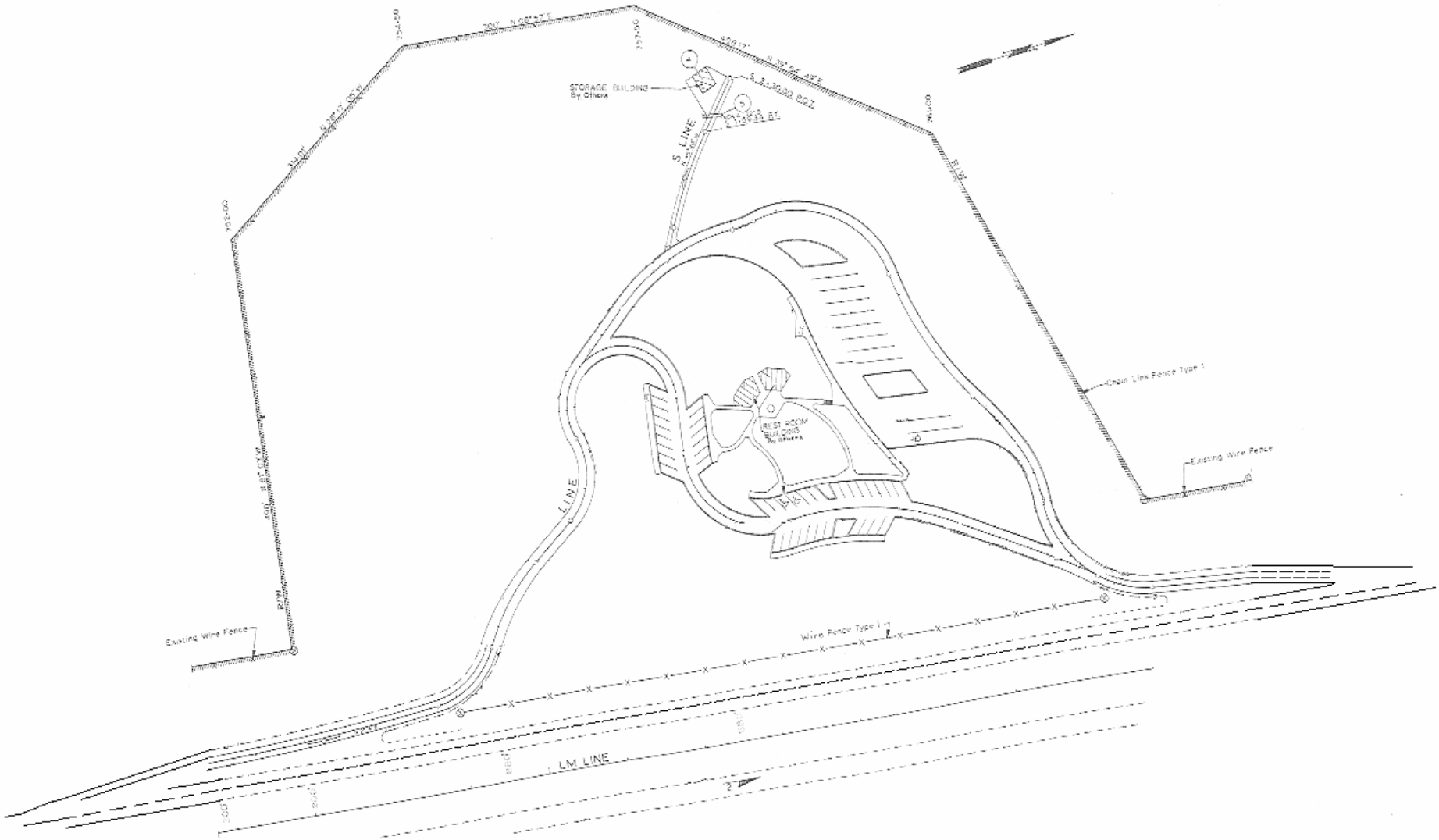
Additional Illumination (8 & 9)

- Bridges:
  - Justification for illuminating bridges is the same as that for highways, with or without full limited access control, as applicable.
- Railroad Crossings Without Gates or Signals:
  - Illumination is justified if there is a potential for nighttime accidents.
  - Take into consideration the extent of nighttime activity.
  - Consider illumination if there is a probability that railroad cars will be stopped on the crossing at night.

Additional Illumination (10 & 11)

- Walkways and Bicycle Trails
  - Illumination is justified if the walkway is a connection between two highway facilities.
  - Consider illuminating existing walkways or bicycle trails if security problems have been reported.
  - Consider illuminating of new construction walkways or bicycle trails if security problems are anticipated.
- Rest Areas
  - Provide illumination for the roadway diverge and merge sections and illuminate the parking areas as for a major parking lot.

Rest Area



AI 10&11 DM 840-5

Major Changes to Illumination Design Practices

- **A deviation to not provide illumination required for full design level (or to provide more) on a NHS highway requires approval by the Assistant State Design Engineer. (CC: a copy to Toby Rickman MS 47344)**
- **Design deviations on Non-NHS highways are approved by the Regional Administrator.**
- **Maximum Veiling Luminance calculation required on all designs. (design with uniformity requirements - fig. 840-6)**
- **Nighttime light level requirements for short tunnels on continuously illuminated roadways are the same as the light level required on the roadway outside the tunnel.**
- **Illumination of intersections without channelization is justified.**

Major Changes to Illumination Design Practices - continued

- **Pedestrian activity levels defined & factored into light level calculations.**
- **Maximum Uniformity Ratio requirement (avg/min) has been increased to 3:1 in most cases.**
- **Luminaire is not required to be mounted over edge stripe.**
- **Mounting height of light standard no longer required to be called out. Use of 40’ or 50’ light standards is required.**
- **Voltage drop tables removed from Traffic Manual. Conductors are sized using formula: 2ALR.**
- **Illumination design section of Traffic Manual moved to Chapter 840 Design Manual.**
- **Hand calculation method removed and electronic calculation example provided for illumination design.**

Reference Materials

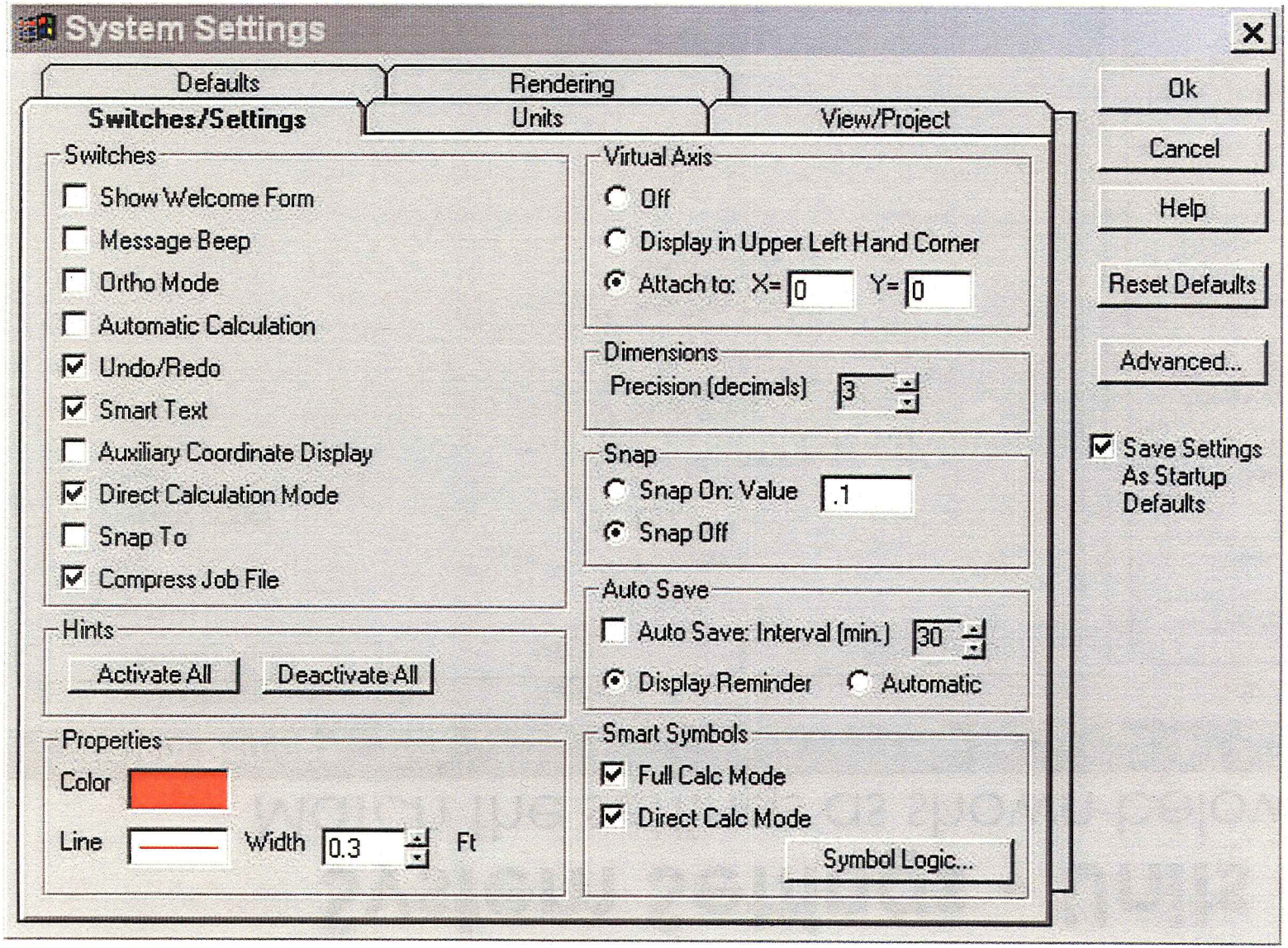
- An Informational Guide for Roadway Lighting – AASHTO. 2000 & 1984
- Illuminating Engineering Society of North America (IES) RP-8-00, 2000 and RP-8, 1983
- Tunnel Lighting Design Procedures – FHWA. 1985
- Recommended Practice for Tunnel Lighting – IES. 1996
- International Commission on Illumination (CIE). 1992
- WSDOT Design Manual. 2000
- WSDOT Traffic Manual. 1993

Contacts

- Ed Lagergren – Signals & Delineation Engineer HQ Traffic Office 360-705-7284
- Terry Thayer – HQ Traffic Office 360-705-7290
- Ted Bailey – HQ Traffic Office 360-705-7286

System Settings - Switches/Settings

Match the settings as shown below.



System Settings - Units

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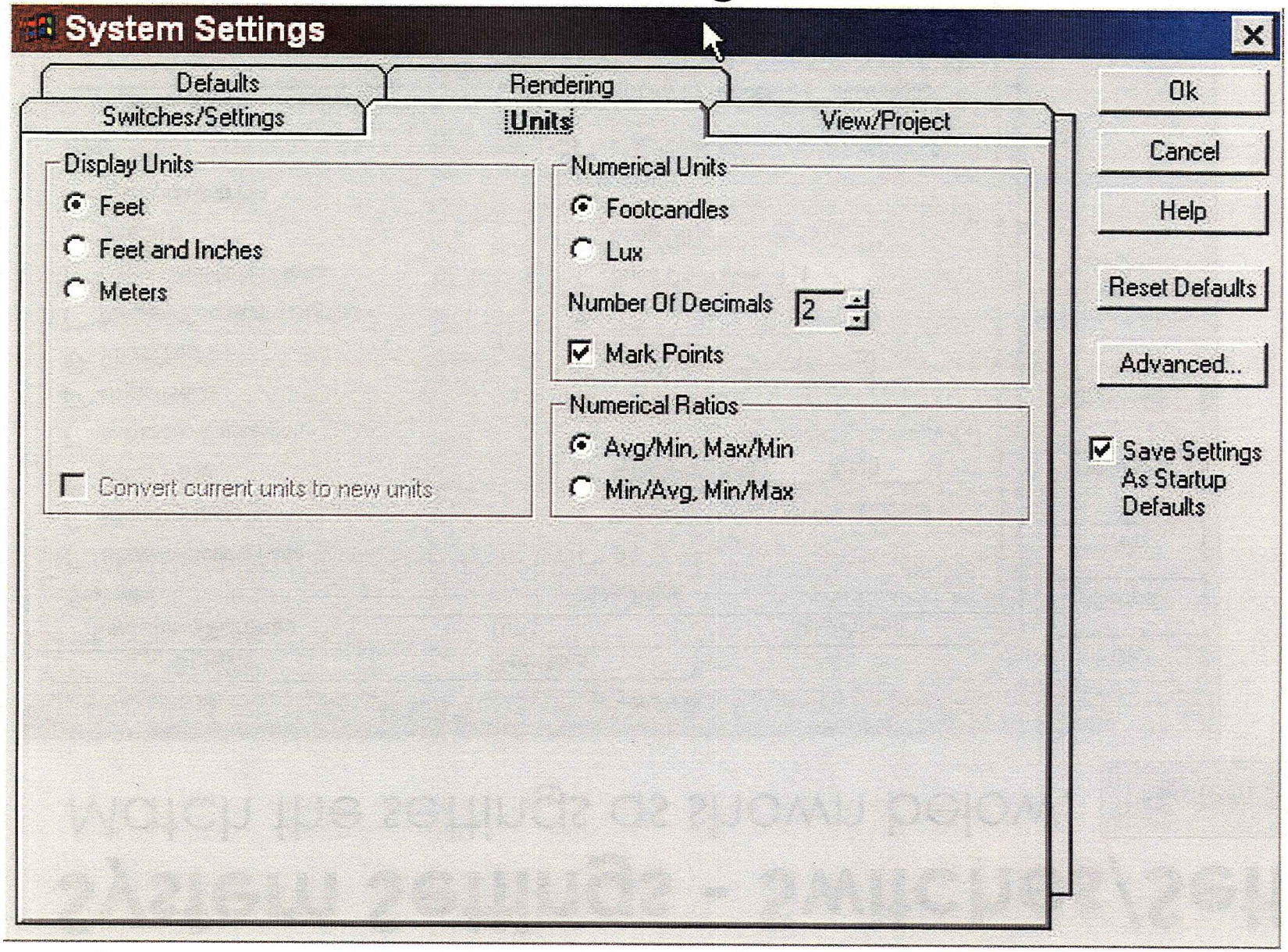

System Settings – View/Project

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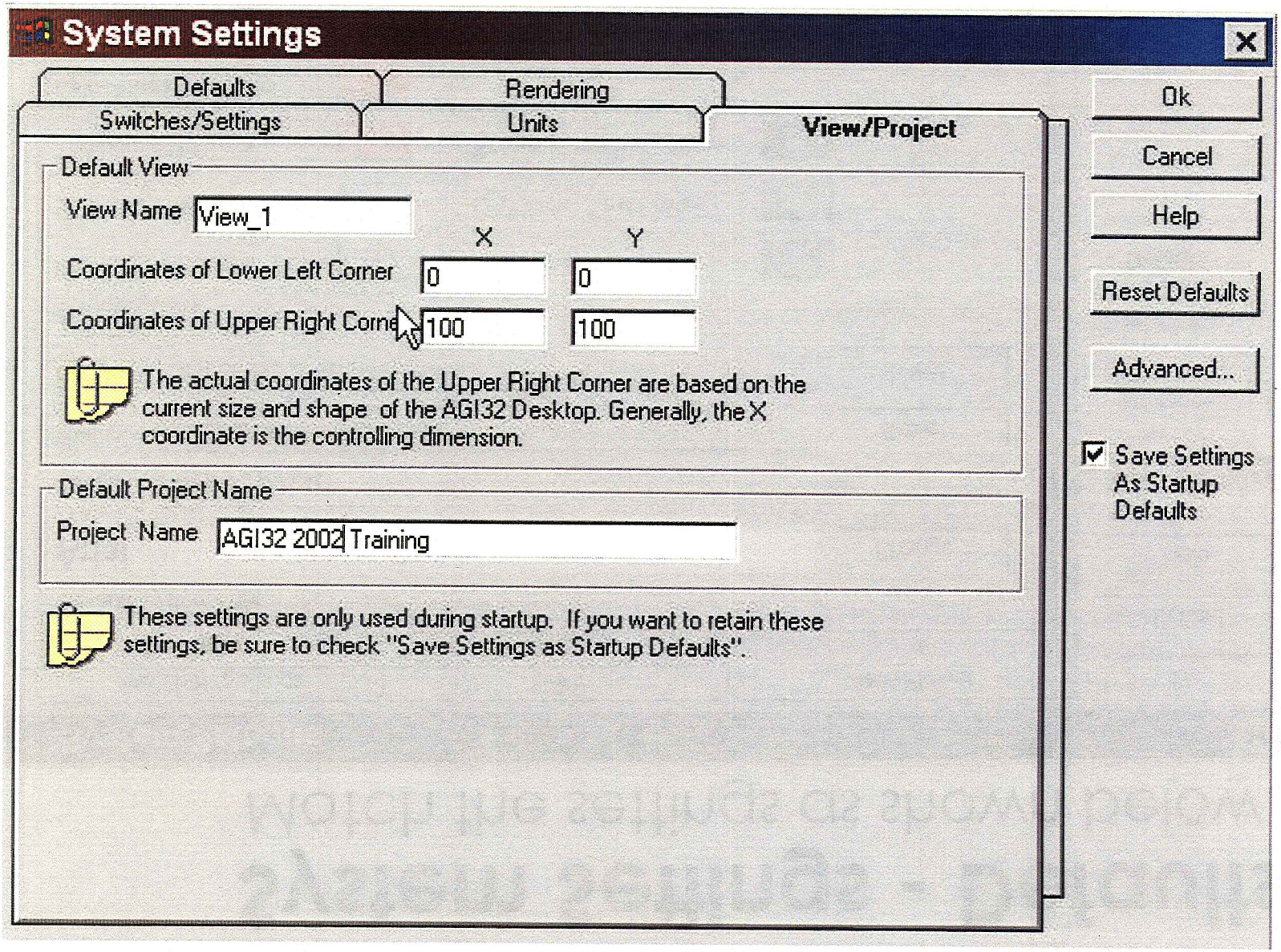

System Settings - Defaults

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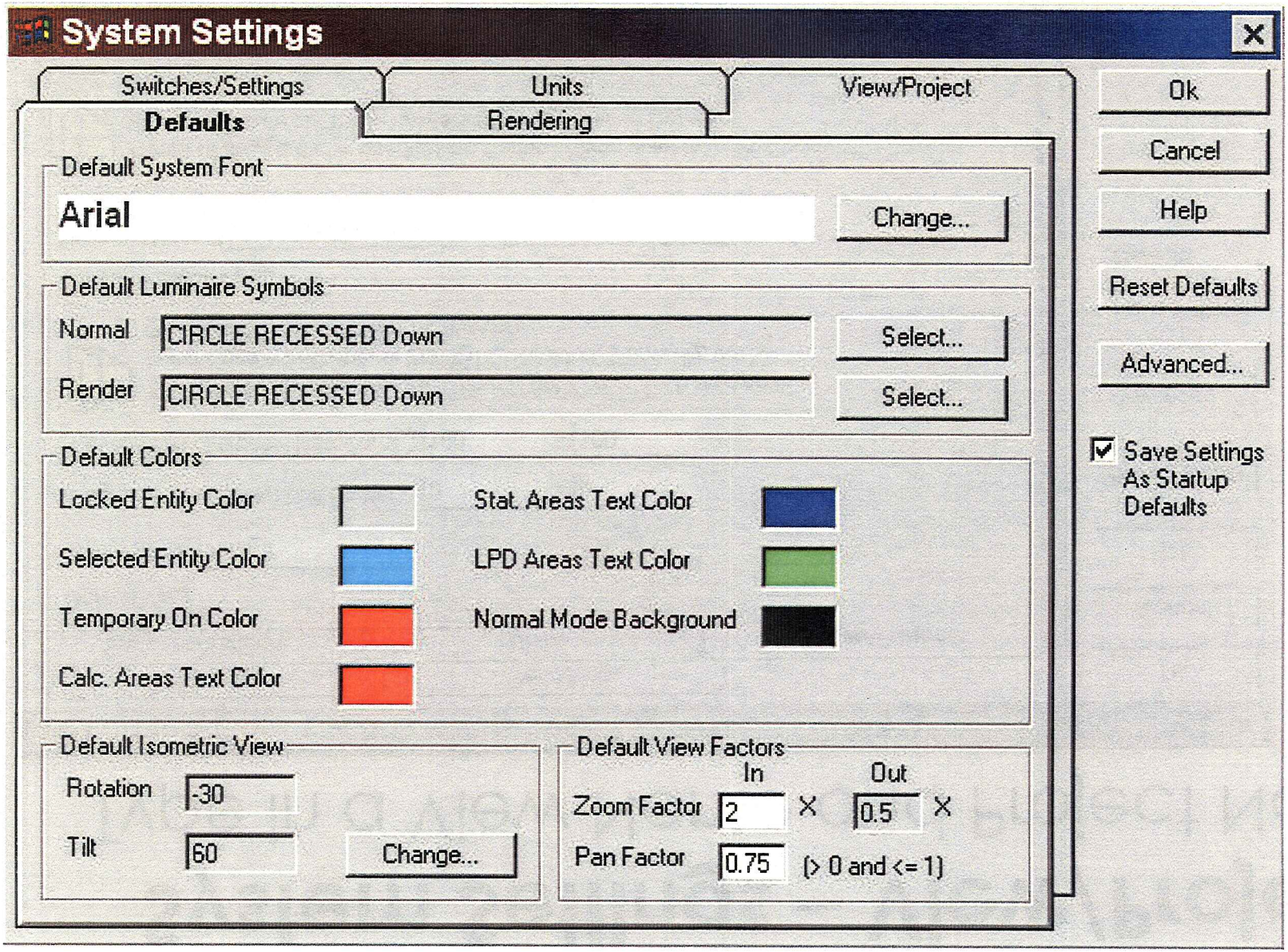

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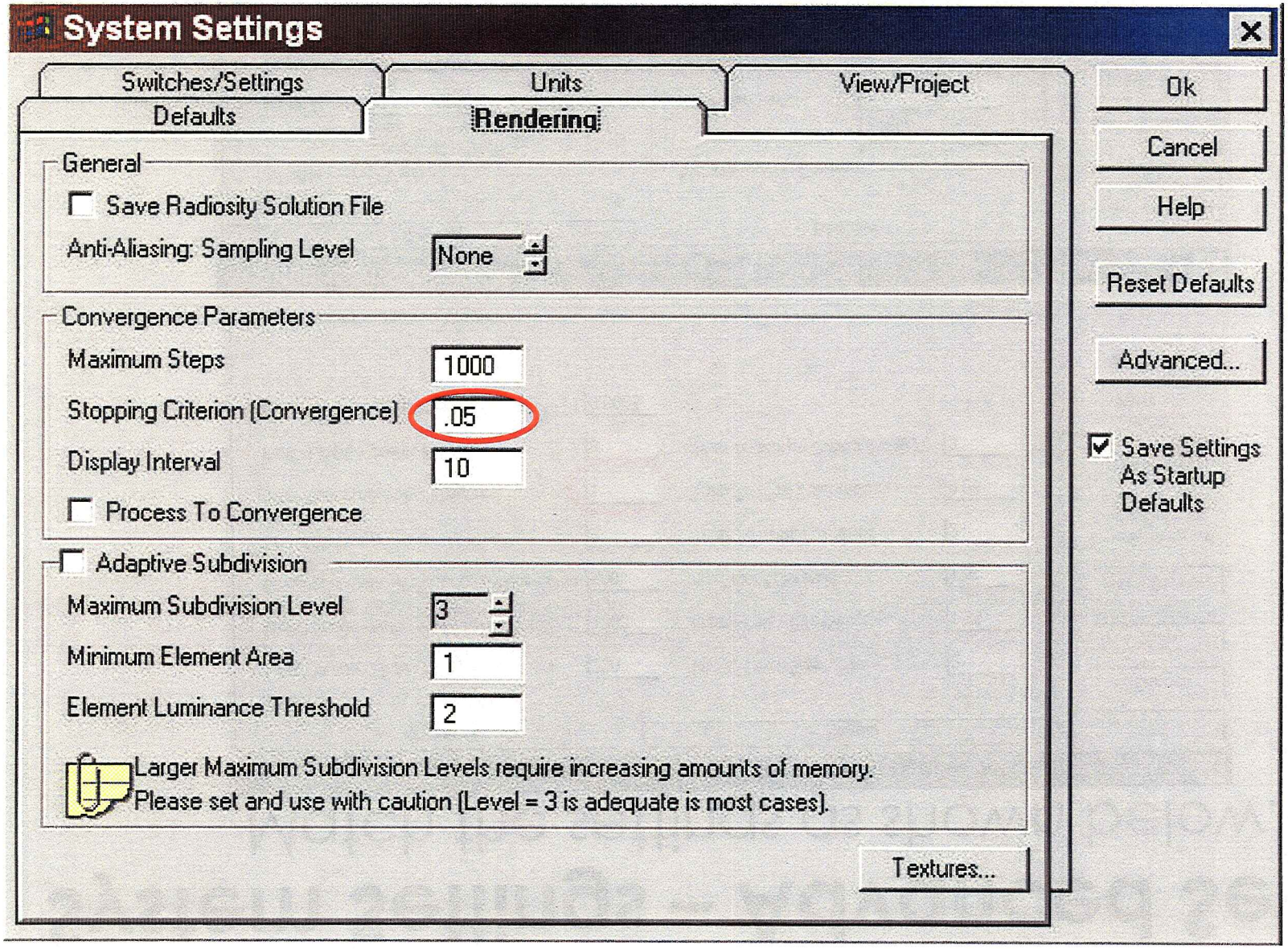

System Settings – Advanced Settings

Match the settings as shown below.